The City of New York
Mayor Bill de Blasio

Mayor's Office of Sustainability

NEW YORK CITY'S ENERGY AND WATER USE 2013 REPORT

AUGUST 2016

urban green
U.S. GREEN BUILDING COUNCIL CHAPTER
CUSP
CENTER FOR URBAN SCIENCE+PROGRESS

Urban Green Council

Urban Green Council is the New York Affiliate of the U.S. Green Building Council. Our mission is to transform NYC buildings for a sustainable future.

We believe the critical issue facing the world today is climate change. Our focus on climate change requires us to improve energy and other resource efficiencies in buildings, creating a more resilient, healthy and affordable city for all New Yorkers.

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This is the City of New York's fourth report analyzing data collected from Local Law 84 of 2009 and its first report analyzing data from Local Law 87 of 2009. This report focuses on 2013 energy and water usage reported in 2014. Both laws are part of the City's Greener, Greater Buildings Plan, designed to reduce greenhouse gas emissions from New York City's largest buildings.

The report was written and designed by Urban Green Council at the direction of the Mayor's Office of Sustainability. Urban Green Council and New York University's Center for Urban Science and Progress (NYU CUSP) performed the data analysis and developed the graphs and charts included in this report. The organization responsible for each graph or chart is listed in its caption.

The individual contributors from each group are included in the report's Appendix.

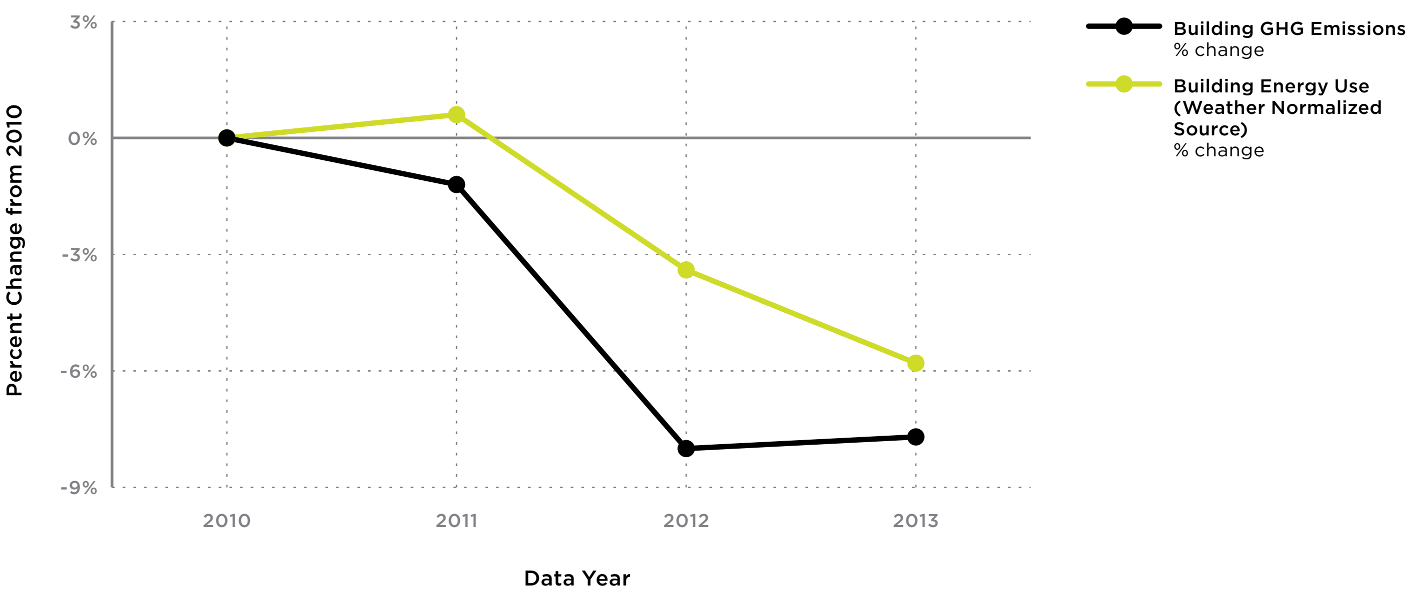
EXECUTIVE SUMMARY

SINCE 2010, NEW YORK CITY'S LARGEST BUILDINGS HAVE CUT THEIR ENERGY USE AND THEIR CARBON EMISSIONS.

Six years ago, as part of its efforts to cut carbon emissions from New York City's largest source, energy used in buildings, the City of New York (City) launched a groundbreaking initiative to determine how much energy its largest buildings use. Since then, Local Law 84 of 2009 (LL84) requires owners and managers of buildings that occupy at least 50,000 square feet to report the amount of energy and water these buildings use each year. This information can be used to compare the buildings' energy performance against that of similar buildings.[1] This process of reporting and comparison, known as benchmarking, has since been adopted by many major cities, including Philadelphia, Washington, D.C., and Chicago.

The data the City collects show that the carbon emissions and energy use of benchmarked buildings have decreased over time. Between 2010 and 2013, emissions from 3,000 consistently benchmarked properties dropped by 8 percent, while energy use decreased by 6 percent (Figure 2).[2] This is a noteworthy reduction

Figure 1: Buildings consistently benchmarked under LL84 show strong reductions in both building energy use and carbon emissions.
(Urban Green Council)

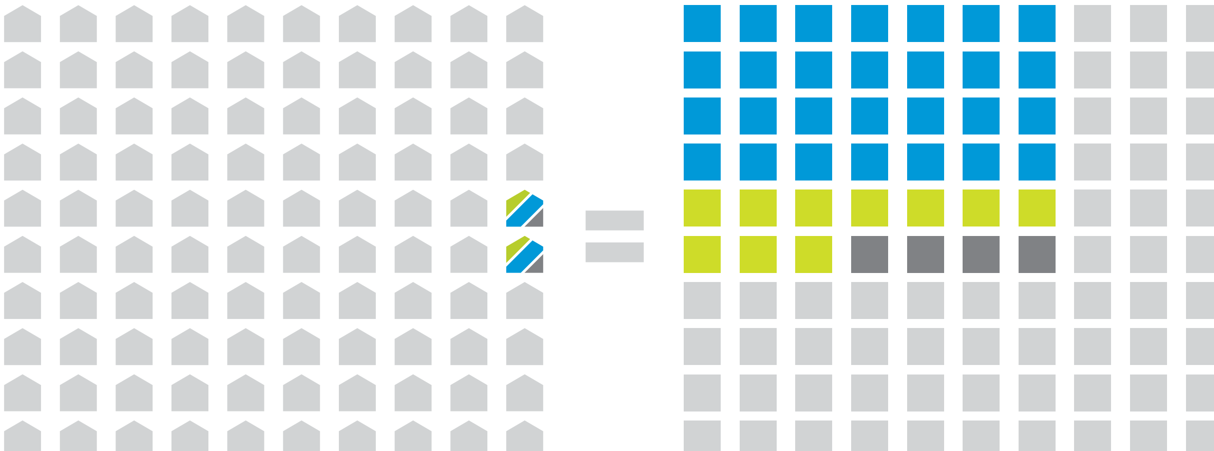


[1] Local Law 84 requires energy and water benchmarking for all large buildings occupying at least 50,000 square feet, or properties with multiple buildings that, together, encompass 100,000 square feet. City-owned properties larger than 10,000 square feet are also required to benchmark each year, but are not included in this report, which focuses on the private sector.

[2] The data displayed here represent only properties that have reported greenhouse gas emissions or weather normalized source energy use data in all four benchmarked years. They represent approximately one-third of all benchmarked properties reporting in 2014 on 2013 use data. These are some of the largest buildings in New York City and they have never been out of compliance with LL84. This result does not account for the energy use and emissions reductions caused by Hurricane Sandy. Emissions calculations use EPA coefficients, not NYC-specific coefficients.

Figure 2: The Number of Privately Owned, LL84 Benchmarked Properties and Their Floor Area by Type of Use.

Though they represent only 2 percent of New York City properties, privately owned, benchmarked properties account for 42 percent of New York City's total square footage. (Urban Green Council)



New York City Buildings Affected by Benchmarking Law (2%)

New York City Floor Area by Type

28% Multifamily Housing 10% Office 4% Other

since the City's 2007 Inventory of New York City Greenhouse Gas Emissions had projected that New York City emissions would increase by 27 percent by 2030 in a business-as-usual scenario.[3]

LL84 requires that roughly 15,000 private and City properties benchmark their energy and water use each year. While these properties account for fewer than two percent of properties citywide, they comprise 47 percent of New York City's total floor area. Privately owned large buildings make up 42 percent of the city's floor area, or about 2.3 billion square feet, an expanse larger than the land area of Manhattan and Staten Island combined.[4]

In 2014, owners and managers of about 10,000 properties submitted enough detail about 2013 energy and water use to be included in this report's analysis.[5] Collectively, these buildings used 120 trillion British thermal units (Btu) of energy. That amount is slightly larger than the energy generated annually by four full-sized electric power plants.[6]

WE NOW KNOW MUCH MORE ABOUT HOW NEW YORK CITY'S LARGEST BUILDINGS USE ENERGY

Benchmarking under LL84 quantifies and compares buildings' energy and water use. But this data on its own does not explain how energy is used by buildings and the systems they employ. Local Law 87 of 2009 (LL87) addresses some of that problem, by requiring owners of large buildings to audit their buildings' energy use every 10 years. These audits record information on building characteristics and energy systems, such as boilers and lighting, offering us an unprecedented first look at how New York City's large buildings use energy.

The City's benchmarking data indicate that multifamily buildings and office buildings consume 87 percent of the energy used in and by New York City's large buildings. For that reason, this analysis concentrates on how these two sectors use energy. The largest sector, multifamily buildings, occupies two-thirds

[3] The City of New York. (2016). Inventory of New York City Greenhouse Gas Emissions in 2014. Retrieved from www.nyc.gov/html/planyc/downloads/pdf/NYC_GHG_Inventory_2014.pdf

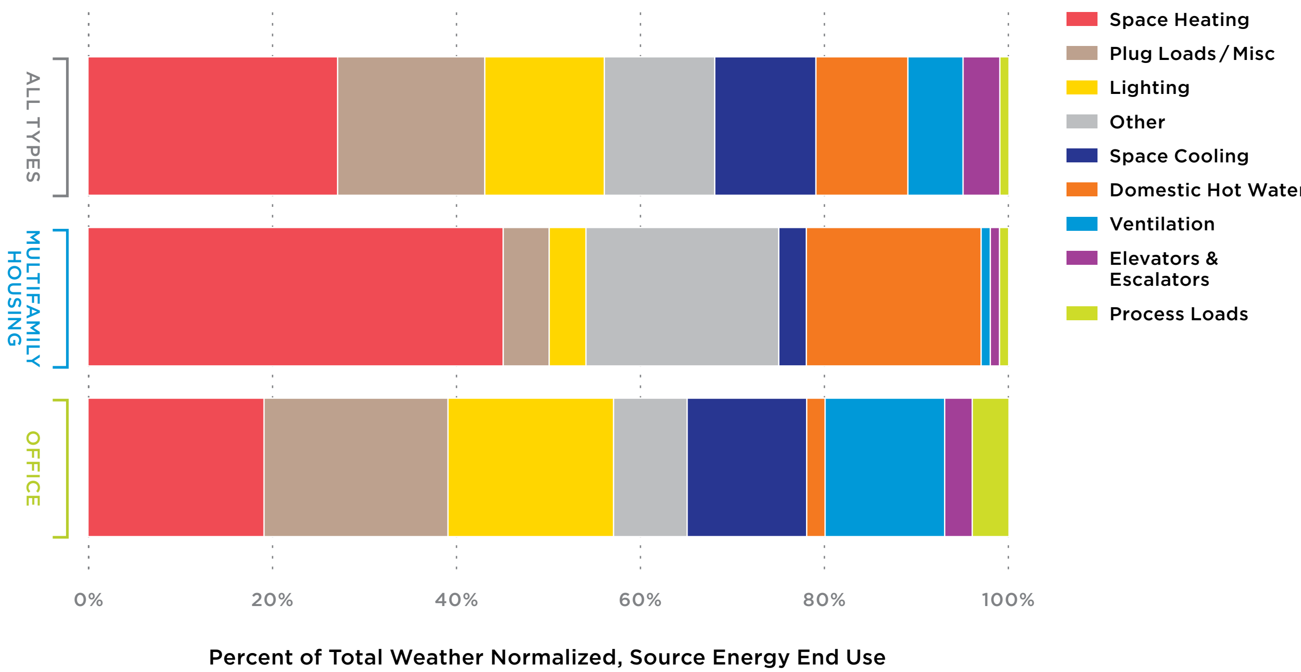
[4] This is based on areas calculated using the Department of City Planning (DCP)'s Primary Land Use Tax Lot Output (PLUTO) database.

[5] Guidelines for data quality are defined in Appendix B under the LL84 data cleaning methods.

[6] A full-sized power plant is assumed to have a nameplate capacity of 1 gigawatt and operate at a 90 percent capacity factor. This is similar to Unit 2 (1.032 GW) and Unit 3 (1.051 GW) at Indian Point Energy Center in Buchanan, New York. Together they produce 55 to 57 trillion Btus annually at a capacity factor of 91 percent. www.safesecurevital.com/about-us/technical-overview.html. https://www.epa.gov/energy/egrid

Figure 3: Energy End Uses by Sector and Overall (LL87 data)

Space heating, plug loads, and lighting are the largest consumers of source energy in large New York City buildings. (Urban Green Council)



of benchmarked floor area—67 percent—and consumes 54 percent of the city's benchmarked energy. Within this sector, two-thirds of the energy used is for heating and hot water, with the remainder used in applications such as lighting, elevators, and cooling. Office buildings, in comparison, occupy 24 percent of benchmarked floor area but consume 33 percent of benchmarked energy. More than half of that energy powers electrical loads, such as lighting, appliances, and office equipment that do not control occupants' thermal comfort (Figure 3).

There are several limitations to this energy audit data. As many building systems are not metered individually, auditors must estimate the amount of energy each type of system uses. Additionally, auditors' reporting on tenant-owned equipment is inconsistent. While some auditors have reported on tenant-owned systems, most have focused on the energy use of the base building systems such as domestic hot water and common area lighting. For this reason, energy use by tenant systems might not have been captured in these estimates. Finally, because LL87 requires building owners to report once every ten years, and collects data from ten percent of covered buildings every year, the City will not have data from all large buildings until at least 2023. Thus, this report provides findings from 20 percent of all large buildings, with data collected in 2013 and 2014.

THE INFORMATION NEW YORK CITY HAS COLLECTED HIGHLIGHTS KEY SAVINGS OPPORTUNITIES

LL87 data captures the types of energy-using building systems employed in large buildings, as well as the prevalence of each type of system. This information, presented in detail in Section 3,[7] serves as a valuable starting point from which to identify savings opportunities. The opportunities specified below apply to the properties that submitted data, and their floor area is described as "audited area."

[7] This order has been determined by aligning LL84 electrical and fuel energy use with the proportion of each end use reported in energy audits required under LL87.

These opportunities include:

- **Improving heating efficiency:** Approximately three-quarters of the city's total audited area uses steam heat, which predominated throughout much of New York City's history but is rarely installed in new buildings due to advances in heating technology. Refurbishing and replacing steam heating systems can yield significant energy savings.
- **Preventing energy losses from window and wall air-conditioning units:** In New York City, nearly half of multifamily buildings' audited area is cooled by air conditioners positioned in windows or walls. Openings between these units and the walls and windows they pass through allow hot air to slip in during the summer and escape in winter. In the multifamily sector, the leakage area associated with room air conditioners is equivalent to a 167,000 square foot hole — an area almost as large as a typical Manhattan block. On an annual basis, this gaping opportunity translates into an operating cost penalty of between $130 million and $180 million for owners and the discharge of 375,000 to 525,000 tons of CO_2 into the atmosphere.[8] Sealing these openings can result in substantial energy savings. So can replacing current units with newer, more efficient cooling technologies during planned renovations.
- **Updating lighting:** Approximately 40 percent of the lit area in audited multifamily buildings and almost 25 percent of audited office floor space is illuminated by inefficient incandescent lighting, or by older, inefficient fluorescent lamps. Upgrading these lights can lead to sizable electricity savings.
- **Installing lighting controls:** Almost all of New York City's audited illuminated area is controlled either by manual wall switches or is lit 24 hours a day, without any controls. As a result, lights often remain on when spaces are not in use. Installing automated controls can save large amounts of electricity. Local Law 88 of 2009 (LL88) requires upgrades to lighting systems for large non-residential properties by 2025, and will eventually address some of these concerns.

LL87 was designed to help building owners and managers understand opportunities for cost-effective energy savings. As part of the audit process, auditors recommend efficiency and/or renewable energy improvements for each property.

In audits filed with the City, auditors' initial recommendations focused on low-cost upgrades that could pay for themselves within a few years. As a result, the audits' projected savings were quite conservative. While it is too soon to know whether auditors' recommendations will be implemented or their savings realized, studies by the New York State Energy Research and Development Authority (NYSERDA) and others have shown that actual savings opportunities are probably larger than those reported.[9]

New York City has committed to reduce carbon emissions by 80 percent below 2005 levels by 2050. To meet this goal, it is relying heavily on emissions reductions from its largest source of greenhouse gases—the building sector. This report enables concerned New Yorkers and others to track this sector's progress using data from the City's benchmarking and energy auditing programs, and to understand how owners and managers of New York City's privately owned buildings can help the City meet this all-important goal.

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[8] Urban Green Council & Steven Winter Associates. (2011). There are Holes in Our Walls. Retrieved from http://urbangreencouncil.org/sites/default/files/there_are_holes_in_our_walls.pdf

[9] Falk, L., Robbins, L., New York State Energy Research and Development Authority. (2010). Results from NYSERDA's Multifamily Performance Programs:20% Reduction in Multifamily Buildings. Retrieved from http://aceee.org/files/proceedings/2010/data/papers/1958.pdf

BACKGROUND AND CONTEXT

Local Law 84 of 2009, part of New York City's Greener, Greater Buildings Plan to cut carbon emissions from New York City's largest source, energy used in buildings, recognizes that the first step to reducing carbon emissions is measuring energy use on a building-by-building basis. Called "benchmarking," this practice of calculating, reporting on, and comparing energy use has, since 2010, been required of all New York City buildings that occupy at least 50,000 square feet of floor area and of properties with multiple buildings totaling 100,000 square feet or more. At the time this report was undertaken, the citywide benchmarking program had collected four years' worth of data. As trends begin to emerge, that data can help policymakers, building owners and concerned New Yorkers identify and target areas for improvement.

To better analyze building energy use, another section of the Greener, Greater Buildings Plan, Local Law 87 of 2009, requires that all large buildings covered by LL84 undergo an energy audit every 10 years. (This auditing began in 2013, with one-tenth of the city's large buildings undertaking these audits each year. The full complement of New York City's large buildings will undergo an audit every decade). Carried out by state licensed architects and engineers, or other certified professionals, energy auditing provides three basic types of information to the City: a breakdown of energy use by function, such as heating or lighting; an inventory of energy-using equipment, such as boilers and light fixtures; and, a list of proposed energy conservation measures that can reduce individual buildings' energy consumption and carbon emissions. LL87 also requires retro-commissioning (RCx), which aims to ensure that building systems operate as efficiently as designed. Due to a variety of issues, the RCx data has not proven sufficiently reliable to be used in the broad survey presented in this report, which analyzes data collected under both local laws.

This report uses benchmarking data from energy and water used in 2010 through 2013 and submitted to the City in 2011 through 2014 (the most recently available reporting at the time this analysis began), as well as energy auditing reports from 2013 and 2014.

The benchmarking data indicate that New York City's large buildings are comprised of an array of building types that employ a wide variety of energy-using systems. Most benchmarked buildings are multifamily buildings. Together, they occupy a full 67 percent of the city's benchmarked floor area. Offices constitute the next largest portion of benchmarked space, 24 percent. Other types of buildings are usually grouped in the City's data as "Other" and make up nine percent of benchmarked floor area. Combined, multifamily buildings and office buildings consume the vast majority of total benchmarked source energy: 87 percent. Multifamily properties consume more than half of that, 54 percent, while offices consume around one-third, 33 percent. While benchmarked multifamily properties significantly outnumber offices, offices use 36 percent more energy per square foot, due to their greater energy intensities and significantly higher electric loads.

As explained in Appendix A, energy use is often reported as energy use intensity (EUI), the amount of energy used per area, measured in thousands of British Thermal Units (kBtu) per square foot. EUI can refer either to "site energy," meaning the total energy consumed within a building, or to "source energy," which includes the additional energy needed to generate electrical power. When describing the energy use of any group of buildings this analysis will use the median EUI. As discussed in Appendix A, the median value—half the data points lie above and half below—is most useful in describing how one building compares to its peers: It is immediately obvious whether an individual building is above or below the midpoint of the set.

Where appropriate in this report, data for individual building sectors are further divided by their size: low-rise buildings with seven or fewer floors; high-rise buildings with eight or more floors; and, very large buildings that are larger than 500,000 square feet, regardless of the number of floors. The division at seven floors is common in building analysis in New York City since this is the height at which buildings need more complicated building systems, such as elevators. The very large buildings tend to use more complicated and centralized building systems. The systems used in each group varied significantly within the LL87 data, and understanding those differences can lead to the development of more targeted approaches and recommendations for building system improvements.

Benchmarked data for individual buildings are public and available online.[10] This report adds to the usability of this data by offering a comprehensive look at benchmarking data as well as building energy data available to date. This includes private energy audit data and other data not readily available online. The analysis of this data provides:

- historical and sector comparisons of large building energy use;
- prevalence of energy systems in audited buildings;
- summaries of auditors' estimates of potential savings from technical improvements;
- recommendations for ongoing improvements in the City's reporting requirements; and,
- recommendations for the use of these results to help create ongoing reductions in large building energy use throughout New York City.

[10] New York City Mayor's Office of Sustainability. Data Disclosure & Reports. Retrieved from www.nyc.gov/html/gbee/html/plan/ll84_scores.shtml

UNDERSTANDING ENERGY USE AND IMPROVING ENERGY EFFICIENCY IN LARGE BUILDINGS

The analysis of data from both benchmarking and energy audits now gives us a first look at how large New York City buildings use energy, along with opportunities for improvement, and in so doing, is the first step to cutting carbon emissions.

Importantly, the data show that electricity constitutes more than half of the source energy consumed in benchmarked buildings—59 percent. Natural gas accounts for 24 percent and Con Edison's district steam system, confined to Manhattan,[11] accounts for 6 percent. The largest end uses of benchmarked energy are space heating, at 27 percent; combined plug loads and miscellaneous, at 16 percent; lighting, at 13 percent; space cooling, at 11 percent; domestic hot water, at 10 percent; and, ventilation at 6 percent. The remaining 17 percent is used to drive process, conveyance, and other loads (Figure 4).[12]

It is worth noting that these end use loads are auditors' estimates, based on engineering analyses and reviews of metered fuel and electric use. They are not measurements, as these functions are not metered individually. The results should be considered a start to understanding building energy use rather than as precise values.

The key end use findings are:

- The variation in energy uses results mostly from the types of activities carried out in buildings. In multifamily buildings, the largest energy user is space heating. Offices, by contrast, use the most energy to run their computers and other electrical equipment.
- Plug loads, the energy used by products that are plugged into electric wall outlets, are the second largest end use overall, followed by lighting.
- Fuel oil and steam, the most carbon-intensive energy sources, still make up a substantial portion of source energy.

LL87 audits also include inventories of energy-using building systems, such as heating, lighting, and cooling. This report examines the fraction of total audited area that is served by each specified

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[11] Con Edison supplies steam to customers from the southern tip of Manhattan to 96th Street on the west side and 89th Street on the east side": Con Edison. Con Edison Steam Energy Brochure. Retrieved from http://www.coned.com/steam/PDF/SteamEnergyBrochure.pdf

[12] Process loads (e.g., kitchen refrigeration) consume energy in support of manufacturing or commercial process other than conditioning spaces and maintaining occupant comfort. Conveyance loads (e.g., elevators and escalators) consume energy to move people and other resources in buildings.

[13] For lighting, auditors reported the fraction of floor area served by different lighting types. For all other systems, such as domestic hot water and cooling, large buildings include base building systems that serve common needs, such as heat and hot water, as well as smaller, tenant systems, such as window air conditioners and lighting, that serve tenant spaces. As expressed in Section 2, audits focused on inspecting base building energy systems but did not consistently sample tenant space energy systems, thus limiting an accurate representation of whole building energy use.

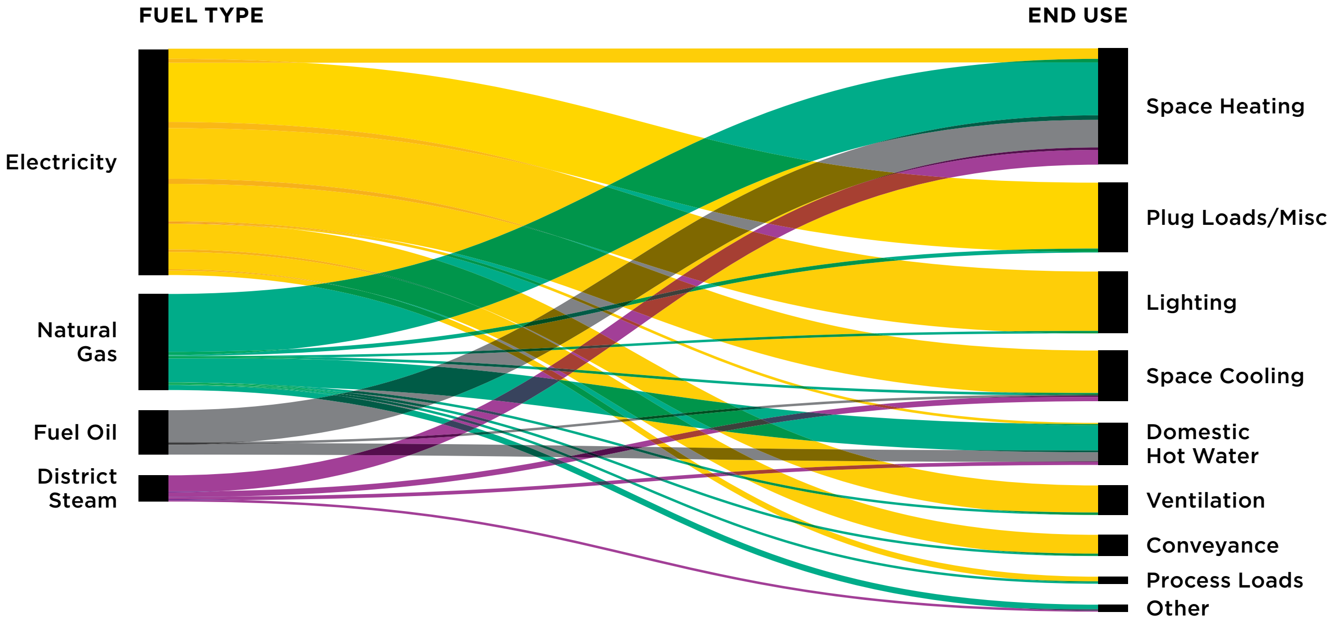


Figure 4: Flow of Fuel Types to End Use (LL84 and LL87 data) [14]
Electricity represents more than half of the audited source energy, while space heating, fueled mainly by natural gas, represents the largest end use. (Urban Green Council)

system.[13] While the prevalence of specific systems does not directly predict energy use or savings, it does indicate where large areas are served by less-efficient systems. These systems are introduced, below, in order of their end use energy consumption, representing the order of greatest opportunity for energy savings.

SPACE HEAT GENERATION AND DISTRIBUTION TECHNOLOGIES

Space heating is the largest single end use in New York City's audited buildings, responsible for 27 percent of total audited source energy. Almost all audited buildings rely on natural gas, fuel oil, and/or district steam[15] for their space heating (Figure 6).[16] In fact, nearly 90 percent of the source energy used for heat is derived from these three energy sources, with most of that energy being used to heat multifamily buildings. No matter where this heating takes place, given appropriate building and energy market conditions, more advanced and efficient electrically driven heating technologies, such as heat pumps, can be powered by renewable energy and have a large market in which to grow.

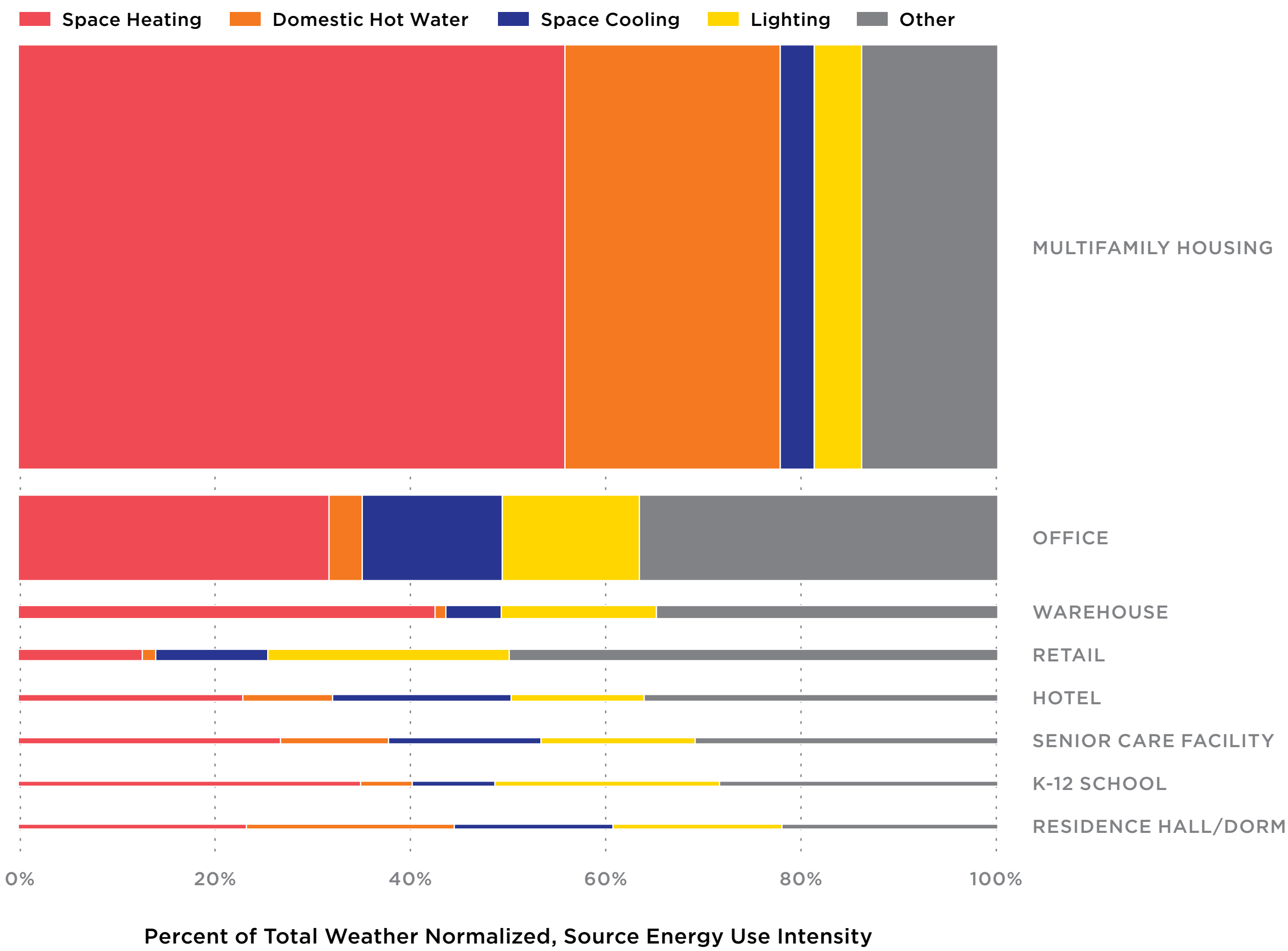
Building steam systems require the combustion of fuel to boil water. The steam is carried through distribution pipes. Steam is used to provide heat in three-quarters of all audited building area and 80 percent of the multifamily sector area. Hydronic systems, which use hot water rather than steam to distribute heat, are currently used in less than 20 percent of audited building area, though their use has increased in buildings built after the 1980s. The other heat distribution systems recorded in the audit data heat air that is delivered to each space in a building through pressurized ducts. These ducts are generally made from sheet metal and attached to the ceiling. Lastly, there are systems that use electric heat pumps or electric-resistance baseboard heaters. A heat pump works like an air

[14] This chart has been created by aligning LL84 electrical and fuel energy use with the proportion of each end use reported in LL87. Natural gas allocated to lighting, plug loads, and other electrical equipment generates electricity in cogeneration plants that are discussed later in this report.

[15] District steam is generated by utility plants and delivered to buildings through underground pipes, losing some of its energy in transmission. The steam becomes liquid water condensate after use, but this hot condensate is not returned to the heating plant. Its energy is lost unless a use is found at the building, affecting the efficiency of the overall system.

[16] The modified Sankey diagram (Figure 6) displays the flow of fuel energy from its sources in the city's utilities, into the different sectors, then into building boilers and furnaces, and finally, into building distribution systems. This diagram was developed using the combination of fuel data from LL84 and system information from LL87, and covers only the energy used for heating in audited properties.

Figure 5: Source Energy Use Intensity by Energy Use Types and Property Type (LL87 data)
(height of bar is proportional to the total area of the property type). Source energy use intensity varies widely by property type. (NYU CUSP)



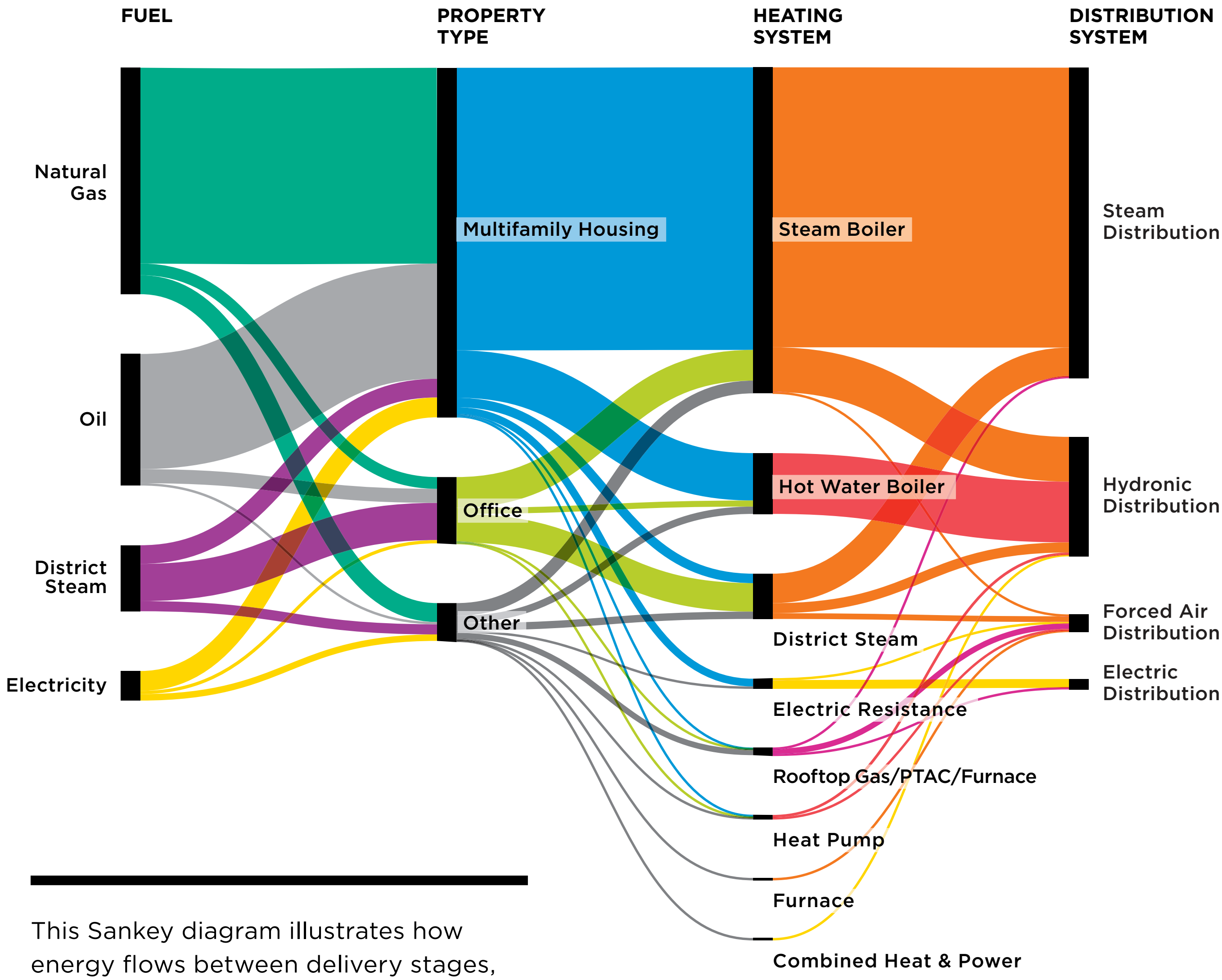
conditioner, moving heat from one place to another. An air conditioner works on the principle that heat and pressure are linked within a contained volume. The refrigerant fluid inside an air conditioner is forced to expand, a drop in fluid pressure causes it to boil at room temperature, in a cycle that removes heat from inside of the building. A heat pump can also work in reverse and provide heat indoors. Baseboard heaters contain electric heating elements enclosed by a metal pipe and fins to transfer heat to the surrounding air.

Because steam heat systems frequently run inefficiently, they offer abundant opportunities for energy savings. Converting steam systems to hydronic systems is effective, but expensive. However, significantly reducing fuel use in most steam systems can be accomplished cost-effectively through operator training, system maintenance, and better functioning controls. The relative EUIs and water use of steam and hydronic systems are presented, below, in Figures 8 and 9.

The heat distribution systems introduced in the diagram on the next page can be broken down further to analyze how different distribution technologies are used in low-rise, high-rise, and very large audited buildings. Electric heat distribution

Figure 6: How Large NYC Buildings are Heated (LL84 and LL87 data)

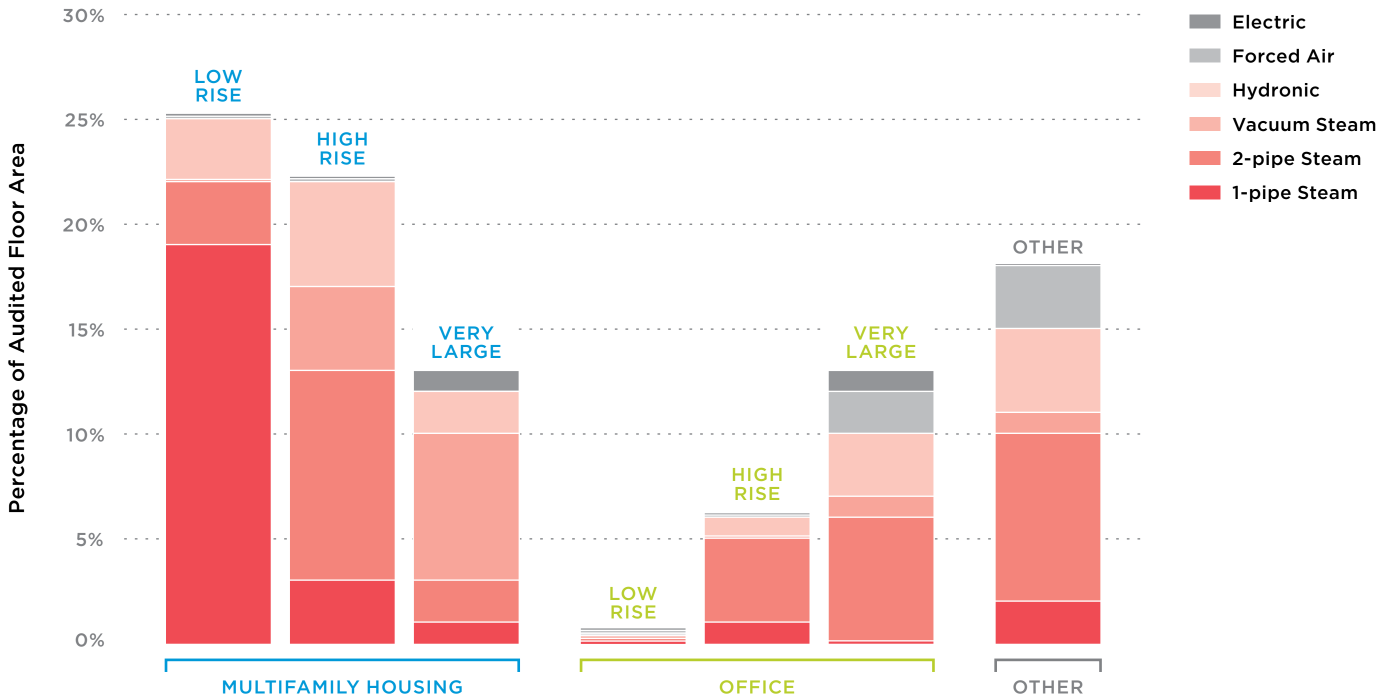
The flow of heating fuel energy through LL87 audited building sectors, heating equipment, and distribution systems. (Urban Green Council)



This Sankey diagram illustrates how energy flows between delivery stages, from origin to end use. The height of the connections between stages shows the proportion of site energy in each category. This flow starts at the left with natural gas, oil, steam, and electricity. It flows to the right into the general property types of multifamily, office, and other. Next, the energy flows into the heat generation equipment used within those properties. The diagram terminates on the right with the systems that distribute the heat.

Figure 7: Space Heating Distribution Systems (LL87 data) [17]

Steam distribution is widely used In large, audited properties, across all property types. (Urban Green Council)



is found in only two percent of audited floor area, mostly in very large multifamily buildings and in office buildings (Figure 7). Electric distribution systems more easily allow for billing based on tenants' use of heat, rather than a flat rate, and generally enable greater tenant control over thermal comfort. This type of heating may use either efficient or inefficient systems. Electric distribution includes electric resistance heat, the same kind of technology found in a kitchen toaster. In general, it is more carbon-intensive than heating with oil, gas, or district steam directly. Other electric systems include electric heat pumps, an efficient and increasingly popular residential technology.

Forced air systems use air instead of water to circulate heat. That is, in forced air heating, a furnace generates the heat from gas, oil, or district steam and a fan distributes it through ductwork. These systems are most commonly employed as part of packaged heating, ventilation, and air conditioning (HVAC) systems, many of which are located on rooftops. These are common in audited low-rise commercial and "Other" buildings.

THE RELATIONSHIP OF HEATING DISTRIBUTION SYSTEMS TO MULTIFAMILY BUILDING ENERGY USE

Because the efficiency of heating systems can vary tremendously, the type of heating system a building employs has a significant impact on its space heating energy use. For example, as reported in the data, steam systems are less efficient than hydronic systems. Even different types of steam systems—one-pipe, two-pipe, and vacuum—can vary significantly in their typical energy use, as indicated by the variation of EUIs found in specific systems in Figure 8. One-pipe distribution sends steam out to building units and returns condensed liquid water to the boiler through the same pipe. Two-pipe steam distribution, generally easier to control and quieter than one-pipe systems, employs one pipe to bring steam heat to units and another to return condensed water back to the system's boiler.

These data are presented in Figure 8 as "violin plots," a smoothed representation of the distribution of energy use intensity for each technology. The quartiles and median EUI are shown as dotted lines. The data show that one-

[17] As referenced in Section 2, the groups of buildings are defined as follows: very large—buildings 500,000 square feet and larger; high rise—buildings under 500,000 square feet with more than seven aboveground stories; and low rise—buildings under 500,000 square feet with seven aboveground stories or fewer.

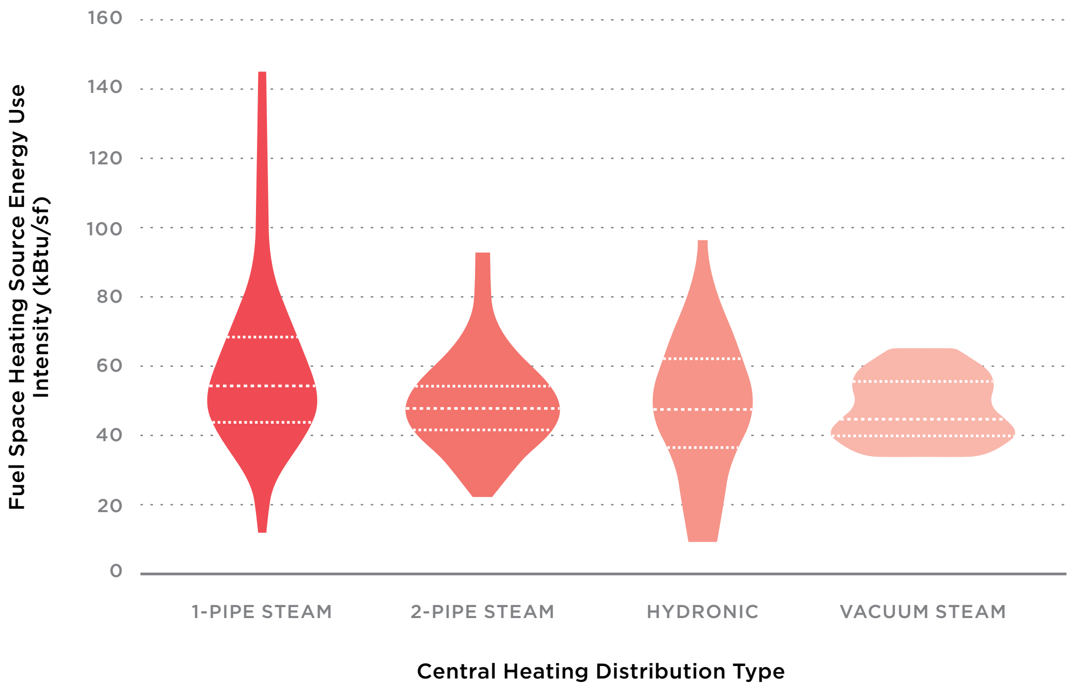
pipe steam systems are the least efficient heating systems. They are prevalent in audited multifamily buildings and heat 37 percent of their floor area. Two-pipe systems typically use less heating energy than one-pipe systems and serve 25 percent of audited multifamily area.

Two other systems that require gas, oil, or district steam—vacuum steam and hydronic systems—each serve approximately 20 percent of the multifamily audited area. A vacuum steam system is a two-pipe system that uses a vacuum pump to enable even greater efficiency and control, while hydronic systems have separate supply and return pipes to circulate hot water through radiators.

Combined benchmarking and auditing data show that the median EUI of multifamily buildings using one-pipe steam heating systems is 13 percent higher than the median EUI of buildings with other principal heating systems.[18] Moreover, the data show a wide distribution in energy use among one-pipe steam systems, as shown below in the long upper tail in Figure 8. These variations indicate a number of inefficiently run systems. The higher energy use found in some one-pipe steam systems may be due to limited operation and maintenance improvements, which minimize top efficiency, or other causes.[19] In contrast, vacuum steam systems

Figure 8: Multifamily Energy Use Intensity by Steam System (LL87 data) [20]

One-pipe steam heat systems appear to use more energy than other audited buildings' distribution systems. (Urban Green Council)



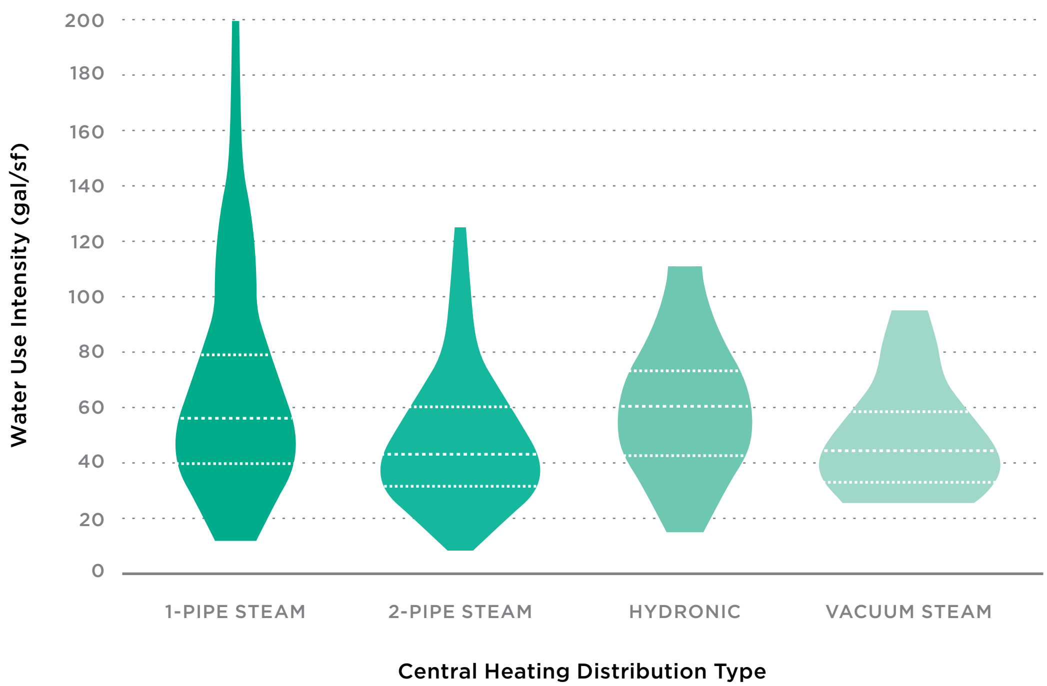
[18] To ensure quality data for this comparison, the audited building submissions were cleaned. Please refer to the Appendix for details on the data cleaning methodology.

[19] Energy Efficiency for All, Steven Winter Associates, & Natural Resource Defense Council. (2015). Clanging Pipes and Open Windows: Upgrading NYC Steam Systems for the 21st Century. Retrieved from http://energyefficiencyforall.org/sites/default/files/EEFA-Upgrading%20NYC%20Steam%20Systems.pdf

[20] The shapes are a smoothed representation of the distributions of system-specific EUI, excluding electricity for pumps, burners, or controls, and any fuel associated with domestic hot water. The width of each violin plot represents an estimate of the likelihood that a building with a specific technology has a certain EUI. That is, based on the data sampled, buildings with two-pipe steam systems are most likely to have a EUI of around 48 kBtu/sf. Stouter shapes means there is less variation in energy use. Long, narrow shapes mean some buildings are very efficient and others are very inefficient. Median and quartile values for each distribution are also shown. The shapes are truncated at the maximum and minimum reported values.

Figure 9: Multifamily Water Use Intensity by Steam System (LL87 data) [21]

One-pipe steam systems are often found in audited buildings with high water usage. (Urban Green Council)



show consistent energy use. This may result from the system being more likely to receive professional maintenance due to its greater complexity, or to other reasons.

Multifamily buildings heated by one-pipe steam systems have a median water use intensity (WUI) nearly equal to that of buildings heated by hydronic systems. (WUI is analogous to EUI and measures building water consumption in gallons per square foot.) However, the distribution for one-pipe steam systems is wider, indicating that a relatively small number of buildings are using very large amounts of water (Figure 9). Many of the buildings in the high tail of the one-pipe steam distribution in the graph above were found to use the flat-rate water billing system. Under flat-rate water billing charges, the water utility charges the same cost regardless of the amount of water used. This system offers little financial incentive to detect and/or repair leaks in the heating system, something that may be one explanation for this high use.[22] More research is needed to determine if this high use could be resolved by fixing leaks in the heating systems of these buildings.

PLUG LOADS AND MISCELLANEOUS

The electricity used by appliances and other equipment is the second largest end use, responsible for 16 percent of total audited source energy. This category will most likely grow even larger as computers and appliances become even more prevalent. Appliances and equipment that use electricity are often referred to as "plug load," because they need to be plugged into wall outlets. The audit data do not track or delineate between specific types of plug load equipment.

Banks and financial institutions that submitted audit data use the most miscellaneous electric energy, with a median use at almost six kilowatt

[21] The violin plot representation of the distribution of water use intensity (WUI) is shown in gallons per square foot per year for each distribution system, and is truncated at the maximum and minimum reported values. Medians and quartiles are shown.

[22] To independently verify that a majority of the buildings with high water consumption are being billed on flat-rate water and sewer accounts, Ashokan Water Services linked the Borough, Block, and Lot (BBL) number found in LL84 and LL87 data to its records in DEP's Customer Information System.

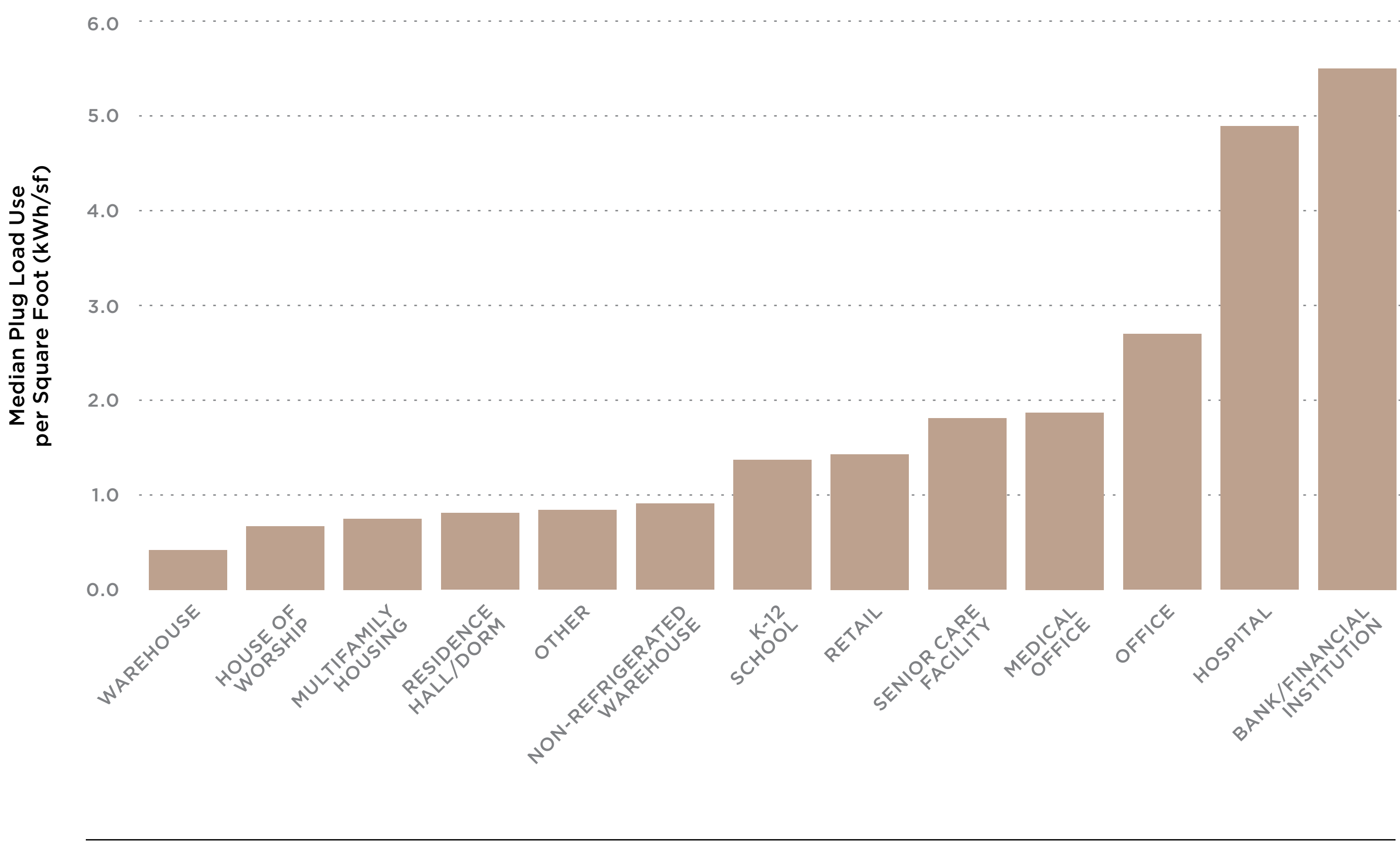
hours (kWh) per square foot (Figure 10).[23] Audited hospitals follow as the second-largest user of plug and miscellaneous loads, at a median of 5 kWh per square foot, due to their intensive use of medical equipment. Audited offices are the third-largest plug load users, with a median of 2.7 kWh per square foot.[24] Absent other changes, that number will likely continue to rise as worker density in office spaces increases. In fact, the average amount of space per office worker in North America dropped by 22 percent from 2010 to 2012.[25] Should this trend continue, other measures of energy use, such as energy per employee, may become more relevant.

INSTALLED LIGHTING TECHNOLOGIES

Lighting is the third-largest user of energy in New York City's audited buildings, responsible for 13 percent of total source energy. There are many new technologies available that reduce lighting energy use while maintaining

Figure 10: Plug Load Density by Property Type (LL87 data)

Audited hospitals and financial institutions use almost twice the plug load energy of typical audited offices. (Urban Green Council)



[23] The loads used by data centers and servers differ from typical plug loads, as they operate with an independent power supply. However, the current auditing tool is not clear on how to report these loads and should be clarified.

[24] This value is consistent with the plug load density found in a detailed 2012 office equipment study. Plug load use density ranged from 2.18 kWh/sf to 10.5 kWh/sf annually: Acker, B.; Duarte, C.; & Van Den Wymelenberg, K. (2012). ACEEE Summer Study on Energy Efficiency in Buildings: Office Space Plug Load Profiles and Energy Saving Interventions. Retrieved from http://aceee.org/files/proceedings/2012/data/papers/0193-000277.pdf

[25] Barron, J. (2015). As Office Space Shrinks so Does Privacy for Workers. Retrieved from www.nytimes.com/2015/02/23/nyregion/as-office-space-shrinks-so-does-privacy-for-workers.html

lighting quality. The multifamily sector, which has the most inefficient lighting installed, has the largest opportunity to save energy through lighting improvements. In fact, 40 percent of the sector's audited area is likely lit by older, lower-efficiency fluorescent lamps and incandescent bulbs (Figure 11).[26] These low-efficiency lamps are used in nearly half of low-rise multifamily audited buildings. And while almost 60 percent of the office-sector audited area is already using higher-efficiency fluorescents, there are still many opportunities for upgrades in high-rise and very large office buildings. For instance, LED lights, the most energy efficient form of interior lighting available, have not yet achieved widespread deployment in the audited area, despite making inroads in every sector.

LIGHTING CONTROLS

Lighting systems with automated controls, including timers, occupancy sensors, and daylight sensors, use substantially less electricity than less-efficient, uncontrolled lighting does. These systems limit lighting to times when it is needed. Most lighting systems in audited New York City properties have no automatic controls (Figure 12). In fact, auditing data show that only 10 percent of buildings have adopted automatic controls, despite the substantial energy-saving potential they offer. Audit reports for buildings did not distinguish manual switches, which must be turned on and off, from lighting that is always on. Timed switches and occupancy sensors make up the majority of the audited control systems currently in use, so there remain many opportunities to use more advanced, energy-saving systems that control lighting based on measured brightness and daylight levels. These more advanced control systems improve lighting quality and can reduce lighting energy use.

This lighting information comes with two important caveats. Though LL87 was written so that energy audits include evaluations of lighting technologies for fixtures and controls in both building common areas and tenant spaces, the data represent mostly building common areas, the most basic requirement for LL87, with not all audits sampling lighting fixtures in tenant spaces. Therefore, the data show both kinds of lighting but focus on common area lighting. Where auditors did not report lighting controls, controls were assumed to be manual switches or lights were assumed to be "always on" and included this way in the chart.

There are great opportunities for savings from lights that are always on in common areas, hallways, stairwells, and other means of egress. The low level of adoption of occupancy sensors in audited multifamily buildings shows a significant opportunity for energy savings, as the use of occupancy sensors in hallways and stairwells is widely regarded as cost-effective.[27] Requirements for lighting controls in recent energy codes and in Local Law 88 of 2009, which requires commercial spaces in large buildings and common spaces in residential buildings to upgrade their lighting to meet code by 2025, will likely lead to wider deployment of these controls in both new and existing buildings.

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[26] Certain anomalies in the data indicate different auditors interpreted the forms used to collect lighting and other energy use information differently, affecting the accuracy of the lighting data. For example, the low percentage of incandescent lighting recorded in multifamily properties may indicate that many auditors did not include information on lighting use in apartments and, rather, recorded only common-area lighting use. A process for improving these forms is proposed in the last section of this report.

[27] McKinsey & Company. (2009). Unlocking Energy Efficiency in the U.S. Economy. Retrieved from https://www.energystar.gov/buildings/tools-and-resources/unlocking-energy-efficiency-u-s-economy

Figure 11: Lighting Technology Systems (LL87 data) [28]

Offices are outpacing multifamily buildings in lighting retrofits. Lighting efficiency varies widely, with the most efficient systems shown at the top of these bar graphs and the least efficient systems at the bottom. (Urban Green Council)

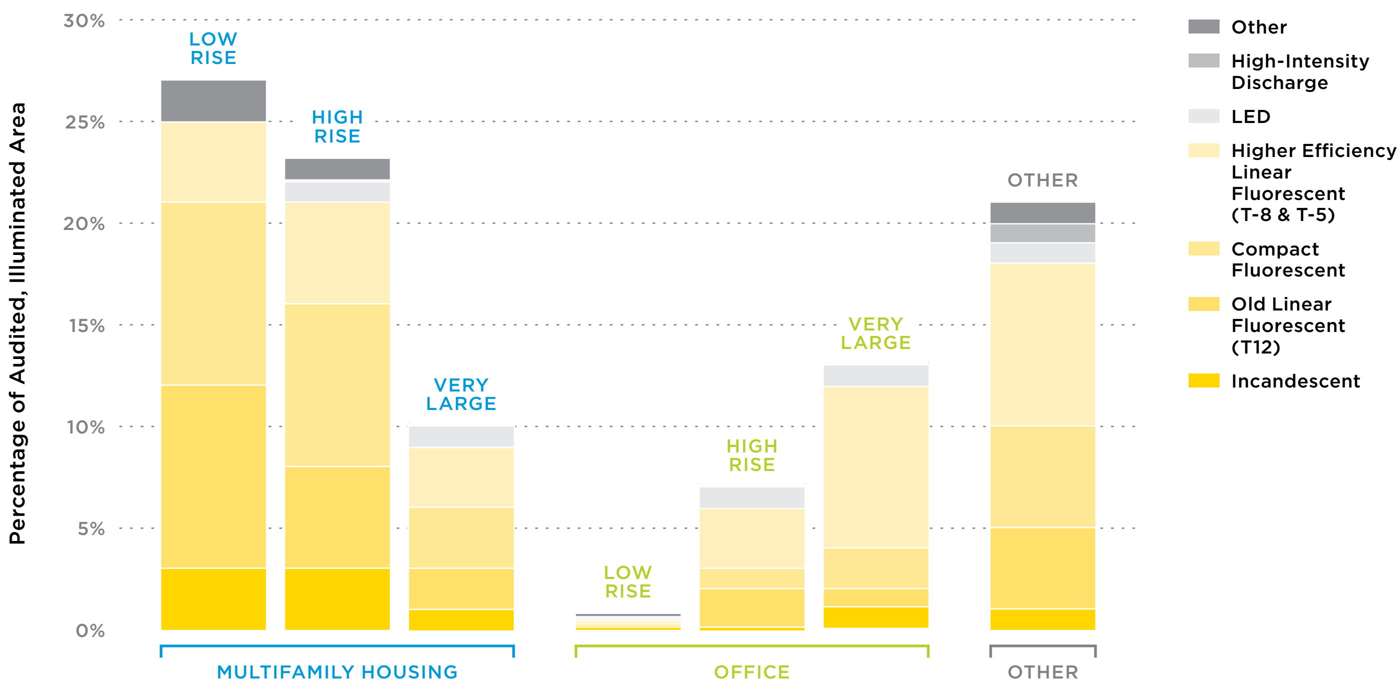
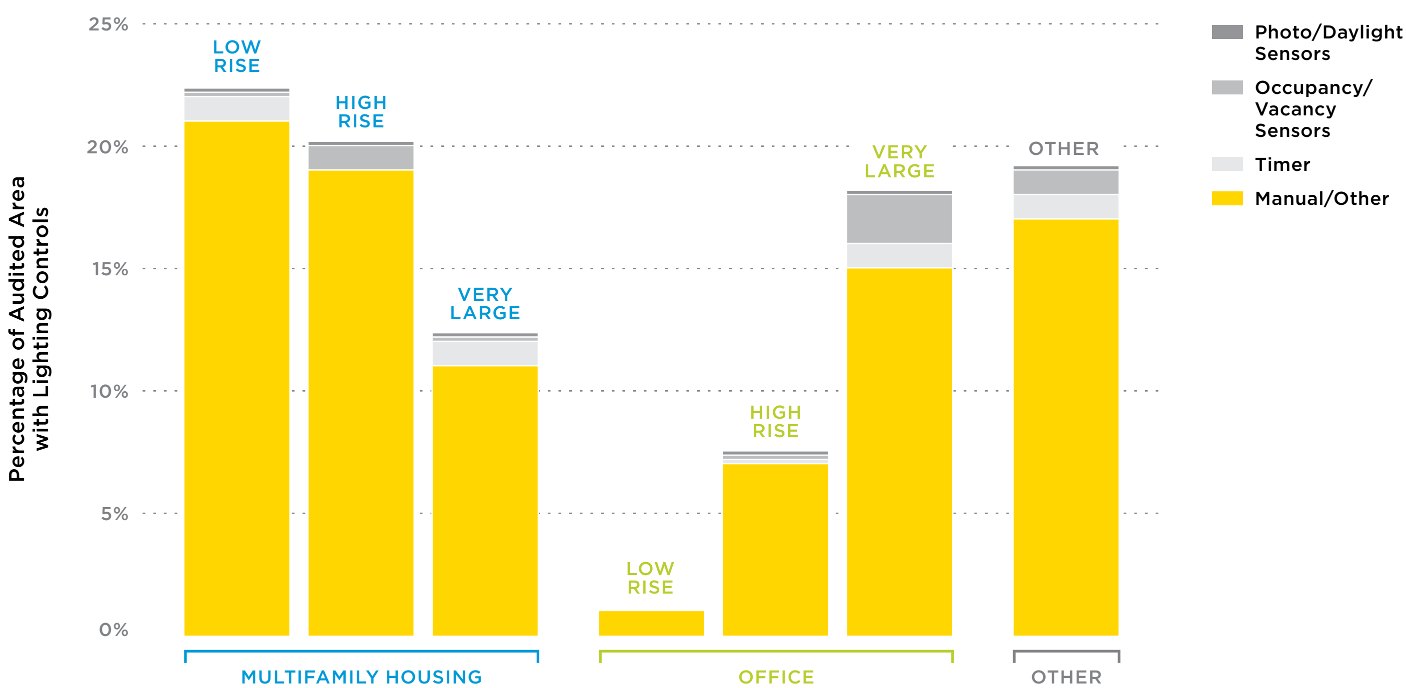


Figure 12: Lighting Controls (LL87 data)

Lighting controls are not widely used. As a result, the bulk of New York City's audited floor area may be lit when lighting is not needed. (Urban Green Council)



[28] "Other" represents complex or uncertain data.

COOLING TECHNOLOGIES

Cooling uses the fourth-most energy in New York City's audited buildings, accounting for 11 percent of the total source energy reported. Nearly 40 percent of audited building area use window air conditioners, through-the-wall cooling units, or packaged terminal air conditioners (PTACs). These are self-contained units with vents and other equipment that go through walls (Figure 13). These systems serve individual rooms and are often poorly sealed, meaning the systems leak heat in the winter and allow heat into conditioned spaces in summer. These systems serve the majority of low-rise multifamily building audited area and half the high-rise multifamily audited area. Many audited office buildings and some very large multifamily audited buildings use central systems that serve either zones or entire buildings. These systems are built into the building infrastructure and serve the spaces they cool at substantially higher efficiency.

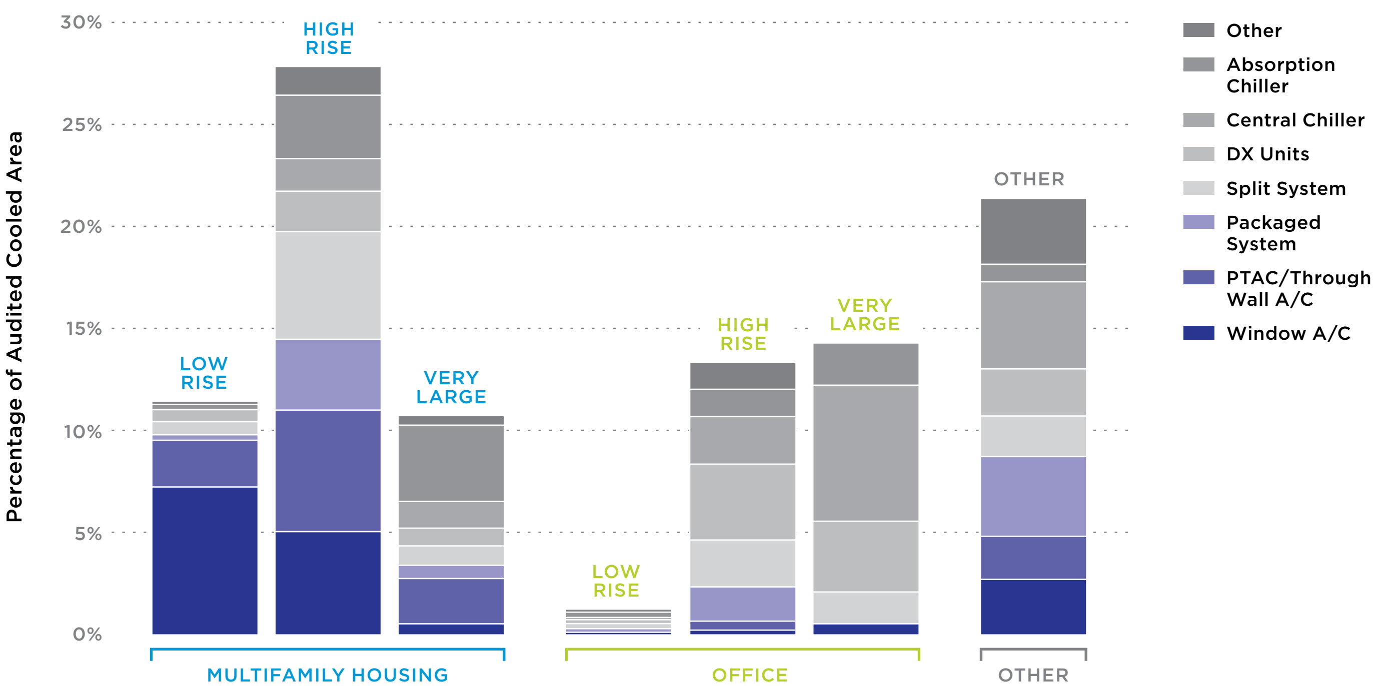
Central plant chillers are used for cooling in half of the audited area in very large office buildings. These plants chill water for distribution throughout a building. The water then enters air-handling units to absorb heat from ventilation air, thus cooling the space. The now-warmed water is then pumped outdoors to a cooling tower or dry cooler to expel its heat. The popularity of these systems in very large office buildings indicates that larger buildings with higher cooling loads and larger floor plates likely benefit from using central plant systems.

Small direct expansion (DX) and packaged units provide cooling to more than 30 percent of audited office space. These units use a technology that is fundamentally similar to central plant chillers, except that they deliver cooled air directly to the conditioned space rather than distributing chilled water to air-handling units. These technologies may be popular partly because they enable building owners to more easily bill tenants for cooling. Separate units also avoid the legal requirement that a licensed operator be present whenever a large chiller is running.

Another type of chiller, called an absorption chiller, is used in about 15 percent of multifamily building audited area. These chillers, which use a thermochemical process to create cooling, are usually less efficient per unit of energy consumed

Figure 13: Cooling Systems (LL87 data) [29]

Individual room systems, such as in-window and in-wall air conditioning units, are common across the audited building cooling landscape. (Urban Green Council)



[29] The areas shown in Figure 13 represent the "area cooled" from the audit data rather than the whole building area. Often, auditors did not report "area cooled" if the primary cooling system was tenant-based, such as window or through-wall air conditioners, underestimating their prevalence in the data presented.

[30] Absorption chillers have reached a coefficient of performance (COP, a measurement of efficiency that compares the amount of power input to a system to the amount of power output) of 1.6: Murakami, S.; Levine, M.; Yoshino, H.; Inoue, T.; Ikaga, T.; Shimoda, Y.; et al. (2006). Energy Consumption, Efficiency, Conservation, and Greenhouse Gas Mitigation in Japan's Building Sector. Lawrence Berkeley National Laboratory. Retrieved from http://escholarship.org/uc/item/6gp873s1

than typical electric chillers,[30] so they are most commonly used where there is a source of free heat or a need to use cooling without increasing electric demand. The presence of a cogeneration plant, which burns fuel onsite to produce both electricity and heat, can make the use of absorption chillers part of a more efficient system and thus financially attractive and more efficient.

Finally, in New York City, split systems cool 15 percent of audited building area and offer very high efficiency cooling. They are relatively new to the United States, but they have been used in Asia for decades.[31] They are called "split" because the components that cool air are placed inside the building while those that release heat are located outdoors. Only narrow tubes connect the two components. This separation improves efficiency and ensures that the building envelopes remain sealed. These systems also allow for zoned billing and do not require a licensed operator. One common form, the mini-split heat pump, enables efficient heating and cooling.

DOMESTIC HOT WATER

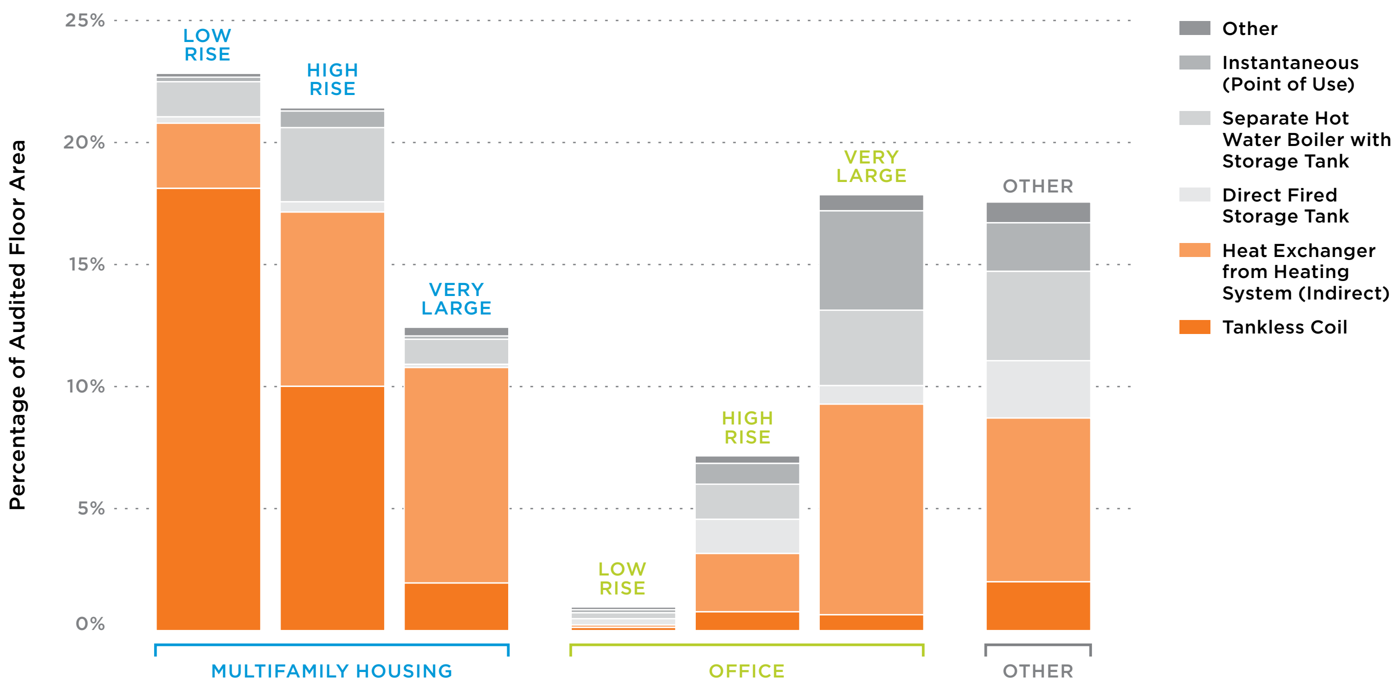
Domestic hot water (DHW) accounts for 10 percent of the total source energy consumption in audited buildings. That portion can be twice as large for residential buildings. The audit data show that improvements to DHW systems can offer energy and financial savings, with simple payback periods of only three years.

A large percentage of multifamily audited buildings rely on their steam boilers to serve both heat and hot water loads (Figure 14). These boilers provide hot water year-round, but operate at lower-than-rated efficiency when used only to heat water.[32] Properly installed condensing boilers dedicated to hot water production operate at very high efficiencies. However, these boilers require dedicated chimneys, something that can add an additional expense during the replacement process.

Instantaneous, point-of-use DHW systems are used in about 20 percent of very large office building audited area, but rarely elsewhere. They use electric resistance to heat water quickly and can eliminate heat loss from supply pipes. So far, solar thermal systems used to heat hot water do not appear in the audit data.

Figure 14: Hot Water Systems (LL87 data)

Most of New York City's audited building domestic hot water is heated using a building's heating boiler, rather than from a separate hot water heater. (Urban Green Council)



[31] Ben-Nathan, O. (2015). Daikin, Mitsubishi, Toshiba VRV / VRF / Split Air- Conditioning Systems - Seamless Integration and Remote Control Operation. Retrieved from http://homeenergypros.lbl.gov/profiles/blogs/daikin-mitsubishi-toshiba-vrv-vrf-split-air-conditioning-systems

[32] The intermittent cycling of boilers during summer months wastes energy: Intermittent Combustion and Boiler Efficiency. Retrieved from www.engineeringtoolbox.com/intermittent-boiler-efficieny-d_1133.html

VENTILATION

Ventilation systems consume 6 percent of audited energy. However, most of this energy consumption occurs in office buildings, as audits of 46 percent of the multifamily building area did not report a ventilation system or declared "Other." In residential buildings, building code requires ventilation only in both kitchens and bathrooms that have no windows.

Most modern offices are not designed to be ventilated naturally and therefore require mechanical ventilation.[33] The audit data show that 98 percent of office area uses ventilation equipment, while nearly half of this area is served by air-handling units (AHU), which move, filter, and heat or cool air. In 29 percent of the total ventilated office area, AHUs were combined with an economizer, which, when outdoor temperatures allow, turns off air conditioning and blows cool air directly into a building's interior. This type of ventilation typically occurs most often in the spring and autumn, when buildings can use outside air to dissipate the internal heat that people, lights, and electrical equipment generate.

Less than 1 percent of multifamily area is ventilated using an energy-saving device called an energy- or heat recovery ventilator (ERV/HRV), though this number is growing.[34] HRVs recover heat from exhaust air before it is released outdoors, while ERVs recover both heat and moisture from exhaust air. Energy-efficient dedicated outdoor air systems (DOAS), which bring in outdoor air but do not condition the space, often incorporate ERVs. These systems appear in 2 percent of commercial building audited area and 5 percent of multifamily building audited area.

WALL CONSTRUCTION AND GLAZING

Unlike boilers and lighting fixtures, exterior walls and glazing are not, in and of themselves, energy end uses. However, how well walls and glazing keep heat out in summer and heat in during winter has a significant impact on the energy use of New York City's buildings. That is because the leakier and less well-insulated windows and walls are, the more energy building systems must use to maintain comfortable temperatures for occupants.

The audit data do not provide information on insulation or sealing within the building envelope. Nevertheless, the prevalence of each envelope type can help to guide the City, building owners and managers, and others who desire to increase insulation and sealing levels throughout New York City (Figure 15).

Mass walls, usually constructed from brick, concrete, and stone, were the most common type of exterior walls found among audited buildings. They were present in 50 percent of audited building area overall. Both low-rise and high-rise multifamily buildings utilize mass-wall construction heavily, with mass walls found in 57 percent of multifamily audited area. In the office sector, 27 percent of audited area employed mass walls.

Thermal mass absorbs solar radiation during the day and then radiates stored heat to occupants after the sun goes down. While the benefits of thermal mass walls are most pronounced in locales with hot days and cold nights, in cities such as New York, thermal mass buildings can lower the morning start-up load for air

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[33] Wood, A.; Salib, R.. (2012). Natural Ventilation in High-Rise Office Buildings: An output of the CTBUH Sustainability Working Group. Retrieved from https://store.ctbuh.org/PDF_Previews/Reports/2012_CTBUHNaturalVentilationGuide_Preview.pdf

[34] There were some inconsistencies in whether the ventilation system was described as one or multiple system types.

Figure 15: Exterior Wall Construction (LL87 data)

Mass walls, usually constructed from brick, concrete, and/or stone, are the most common type of exterior walls found among audited buildings. (Urban Green Council)

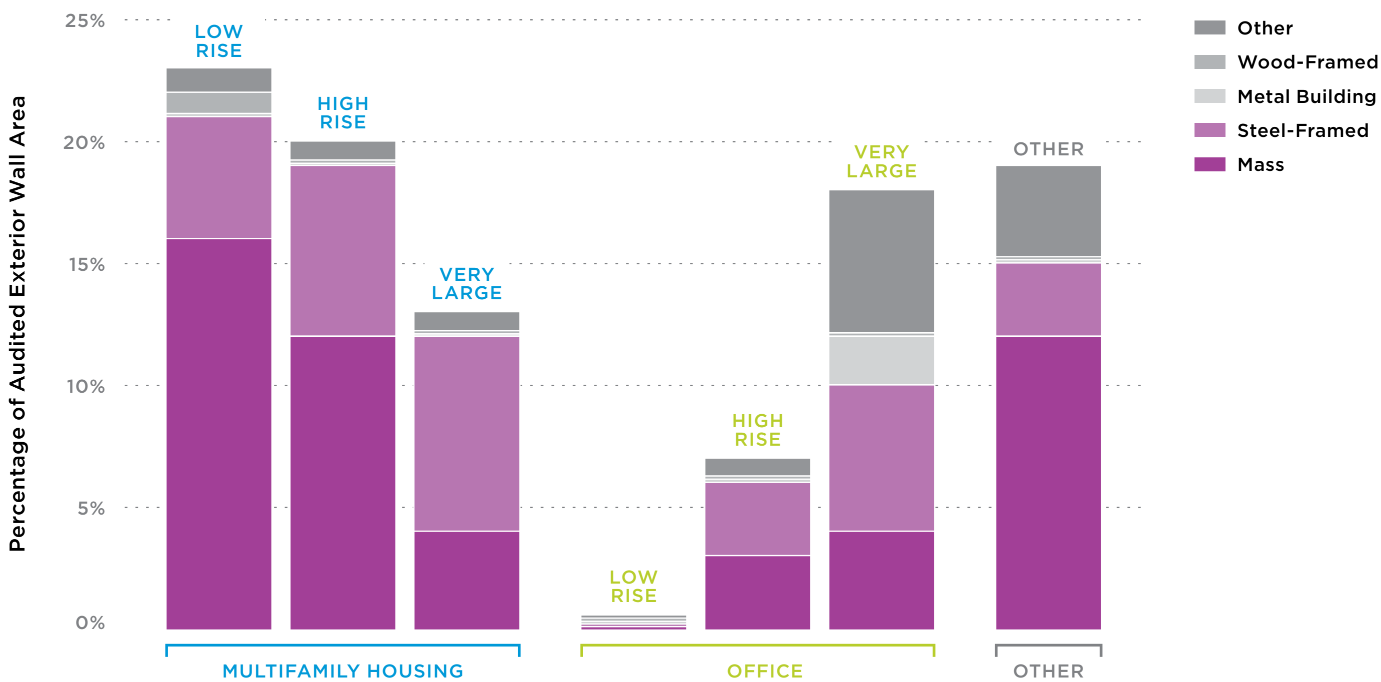
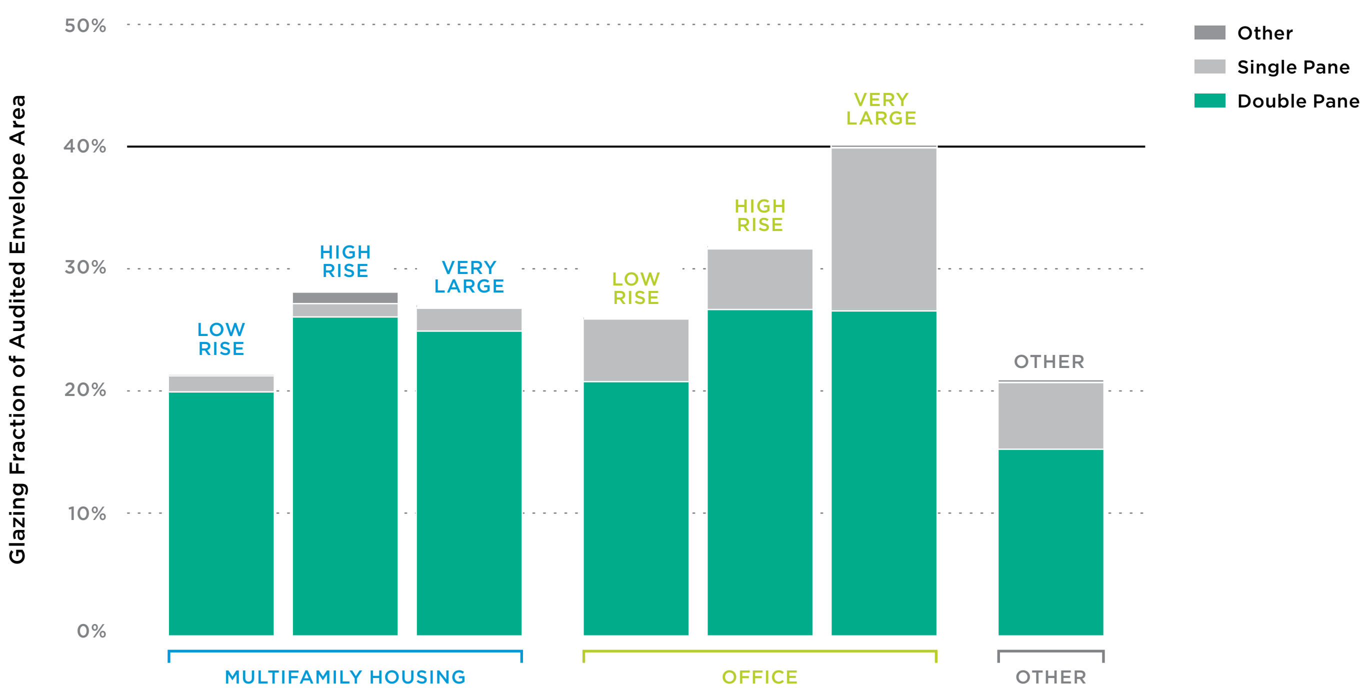


Figure 16: Window Type (LL87 data)

Almost all of the audited New York City windows are double-pane. (Urban Green Council)



conditioning units by absorbing solar radiation and heat from occupants into the walls, floors, and ceiling. This heat increases the temperature of the envelope, but the air temperature may initially remain cool without using any mechanical systems. Moreover, unlike glass curtain walls, mass walls can be easily insulated, helping reduce energy use overall.

Steel-frame buildings, most commonly employing curtain wall construction, are more common in very large residential and commercial audited buildings—those 500,000 square feet and larger. They represent almost 32 percent of New York City's audited building area, and about 35 percent each of audited multifamily and commercial building area.

Windows also have the potential to play an important role in the energy use of New York City's buildings, because their ability to insulate is much lower than most walls. The vast majority of windows in audited buildings were double-paned (Figure 16). Overall, nearly 90 percent of audited glazing is double-paned, with 93 percent of window area in audited multifamily buildings and 74 percent of window area in audited commercial buildings fitting this description.

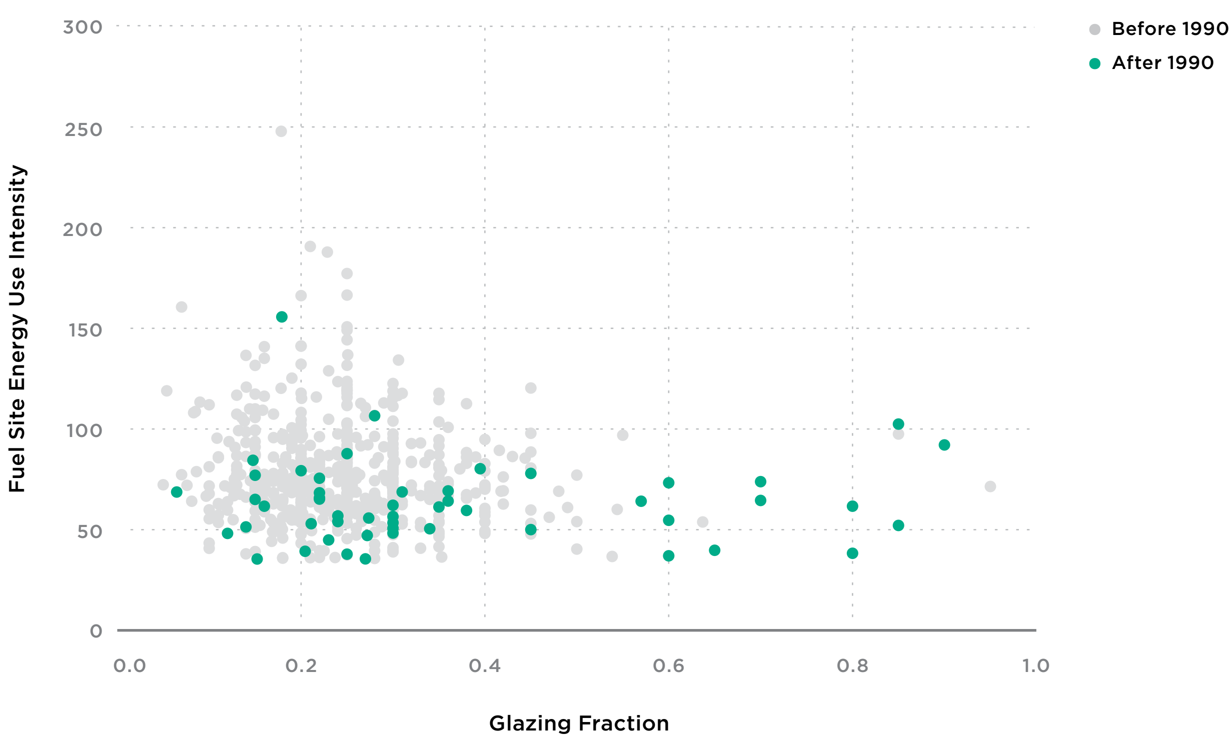
Single-pane glazing, which provides little insulation, is rare in multifamily buildings, at only 5 percent. The larger amount of single-pane glazing in office buildings—26 percent—reflects, in part, the design styles of a group of mid-century modern high-rise buildings that can be difficult to retrofit with double-paned curtain walls. "Other" glazing includes both storm windows and a small amount of triple glazing, usually installed for sound control in newer construction. Both reduce building energy use.

RELATIONSHIP OF WINDOW AREA AND TYPE TO ENERGY INTENSITY

Windows conduct about five times more heat than walls, so buildings with greater window areas are expected to have increased heating and cooling loads.[35] However, Figure 17 shows that for audited existing multifamily buildings with double glazing, fuel use was not strongly correlated with glazed fraction. Cooling energy was not included in this analysis. The green dots in the graph indicate buildings constructed since 1990. This data supports the idea that other thermal loss mechanisms such as infiltration are important in today's buildings. Because of the implications for code design and the contrast

Figure 17: Relationship Between Energy Use Intensity and Glazing Fraction (LL84 and LL87 data)

Most of the audited buildings that have a glazing ratio larger than 50 percent were built after 1990. (Urban Green Council)



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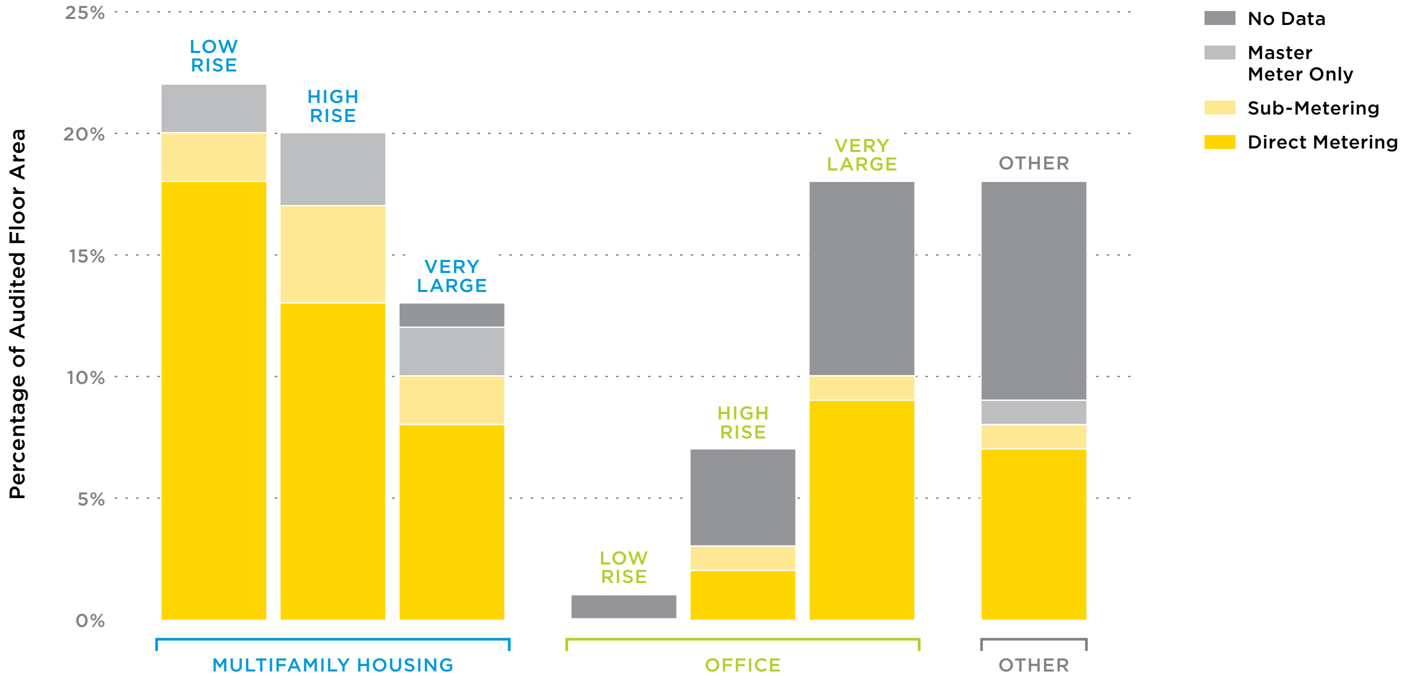
[35] Wilson, A. (2010). Rethinking the All-Glass Building. BuildingGreen. Retrieved from https://www.buildinggreen.com/feature/rethinking-all-glass-building

Figure 18: Types of Electric Metering (LL87 data)

More than half of New York City audited floor area employs direct metering. (Urban Green Council and NYU CUSP)



with the predictions of models, further study using more LL87 data or data from other cities to explore cooling energy use and other factors such as age or effective energy code at time of construction, will be helpful.

BUILDING ENERGY METERING

Metering is the measuring of energy consumption. It enables owners and tenants to understand how much energy they use and allows utilities to bill consumers based on energy use. Simply measuring and communicating energy use information to tenants in buildings of all types can have an impact on how much energy buildings consume. Billing tenants for their energy use creates an incentive for tenants to save money, which can further influence their behavior. LL87 details whether audited buildings are directly metered, master metered, or sub-metered. The difference in energy use in buildings using those various technologies should be a topic for additional analysis.

Fifty-eight percent of the audited building area is reported as directly metered. This means that each tenant space receives a bill directly from the utility company that provides its electricity. This is the most common method of electricity metering in all types of buildings. Another 18 percent of the audited area is mastered-metered, meaning the building owner receives the utility bill and then passes costs down to tenants based on their lease or based on measurements from a sub-meter.[36] Sub-metered spaces make up more than half of this master-metered area in audited buildings.

Finally, 24 percent of the audited building area did not report any metering technology. Determining how these buildings are metered will help owners and managers comply with LL88, which requires sub-metering of commercial tenant spaces by 2025. It will also allow them to better understand, and possibly reduce, their energy use.

[36] New York State Energy Research and Development Authority (NYSERDA). (1997 revised 2001). Residential Electric Submetering Manual. Retrieved from www.submeteronline.com/pdf/subman2001.pdf

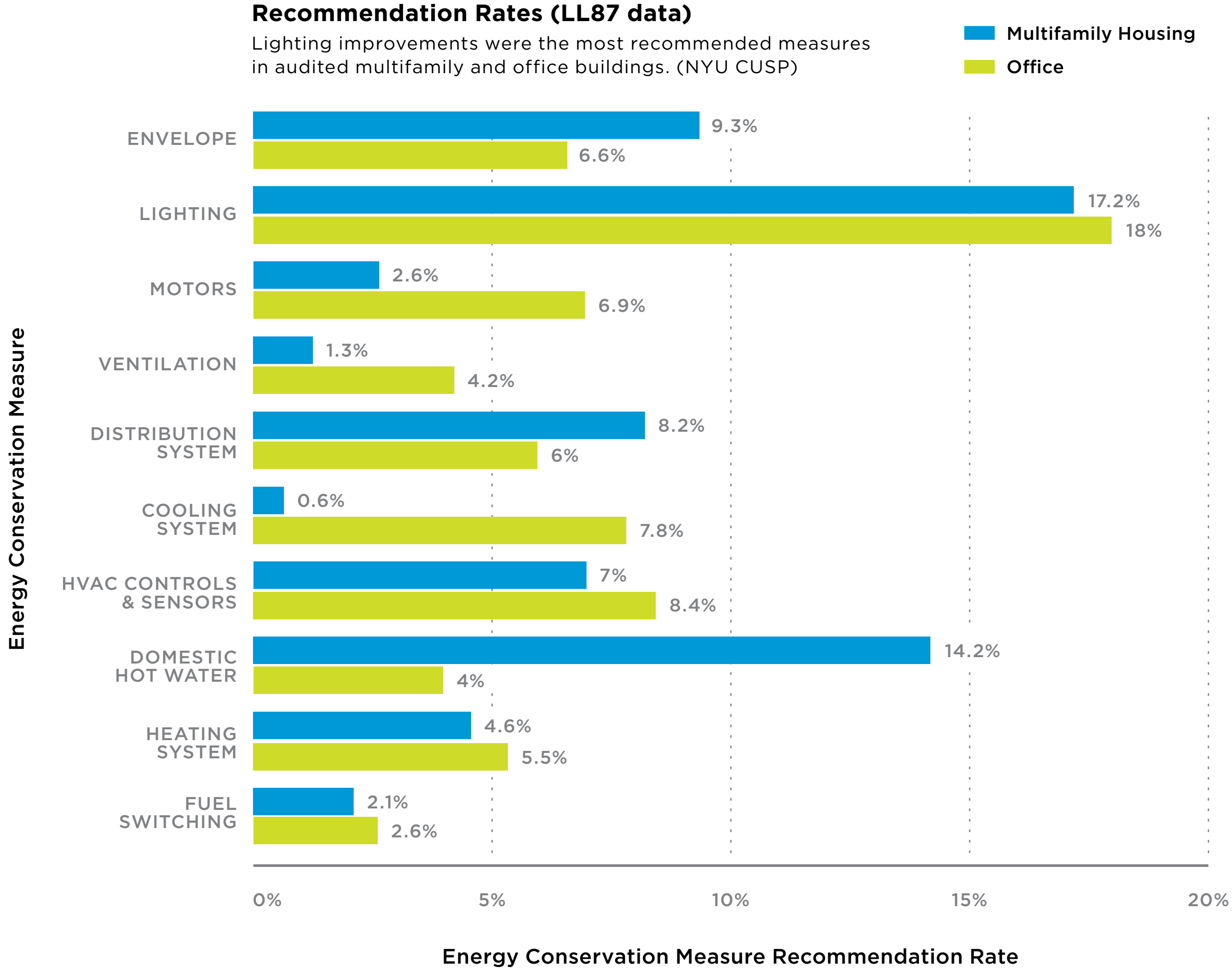
AUDITOR-RECOMMENDED ENERGY CONSERVATION MEASURES (ECMS)

As required in LL87, auditors who assessed energy use in large buildings also recommended improvements called "Energy Conservation Measures" or ECMs. (These measures are listed in Figures 19 through 21.) The individual audit reports present guidance for each building. The results reported here aggregate proposals for many different buildings, and cannot be regarded as proposals for individual buildings. Rather, they indicate promising areas for energy savings and can be used to narrow the focus of an investigation; to check if a specific proposal is consistent with the findings of other engineers; or, to scope prospective government and private utility programs.

Auditors' recommendations may underestimate potential energy savings. For example, universities participating in the NYC Carbon Challenge, a voluntary emissions reduction effort involving some of the city's largest institutions, businesses, and building management companies, have already achieved a 17 percent reduction in carbon emissions across hundreds of buildings.[37]

Figure 19: Energy Conservation Measure (ECM) Recommendation Rates (LL87 data)

Lighting improvements were the most recommended measures in audited multifamily and office buildings. (NYU CUSP)



[37] Universities participating in the NYC Carbon Challenge have already achieved a 17% reduction in carbon emissions across hundreds of buildings: New York City Mayor's Office of Sustainability. The NYC Carbon Challenge for Universities Retrieved from www.nyc.gov/html/gbee/html/challenge/universities.shtml

The auditors' recommendations are fairly uniform in the amount of energy savings they deem feasible and affordable. But they are smaller than both estimates and reported measured savings found in other studies.[38]

Lighting and domestic hot water improvements, the two most highly recommended measures, were recommended for more than half of all multifamily buildings audited (Figure 19). Each ECM category, such as lighting or envelope, incorporates many possible ECMs, so improvements to light fixtures and to controls would both contribute to the lighting ECMs listed. The auditors found lighting and DHW retrofits to be economically attractive, with relatively short payback times.

More research is required to determine the reasons behind auditors' focus on basic retrofit recommendations. One possible explanation is that basic retrofits are more likely to be implemented by owners.

Moreover, auditors' recommendations are meant to be practical and so are sometimes limited by characteristics of the existing buildings. For example, many multifamily buildings are older and have no central cooling or ventilation. While converting to a central system would reduce energy use, replacing window air conditioners with central systems would carry a large capital cost and was not recommended for any of the buildings.

The energy-savings potential across all audited buildings, including each ECM category, totals almost 22 billion kBtu, as shown in Figure 20. These savings are substantial: equivalent to nearly all of the energy used in all of San Francisco's benchmarked commercial buildings in 2014.[39] The building systems that use the most energy are often the ones with the greatest opportunities. Some of the ECMs, such as those pertaining to heating, lighting, and cooling, were more popular and recommended in many audited buildings. Improvements to heating systems in audited multifamily buildings were associated with the largest estimated energy savings overall. Improvements to lighting systems were recommended in almost seven times as many audited buildings as improvements to heating systems but were estimated to save less energy than heating system upgrades. Some of these opportunities, such as improvements to building envelopes, come with high capital costs. There are also some categories that do not directly involve base building systems or common areas, such as plug loads, and as had fewer observations reported by auditors. For example, out of more than 10,000 total ECM recommendations, plug load improvements were recommended in only 104 instances.

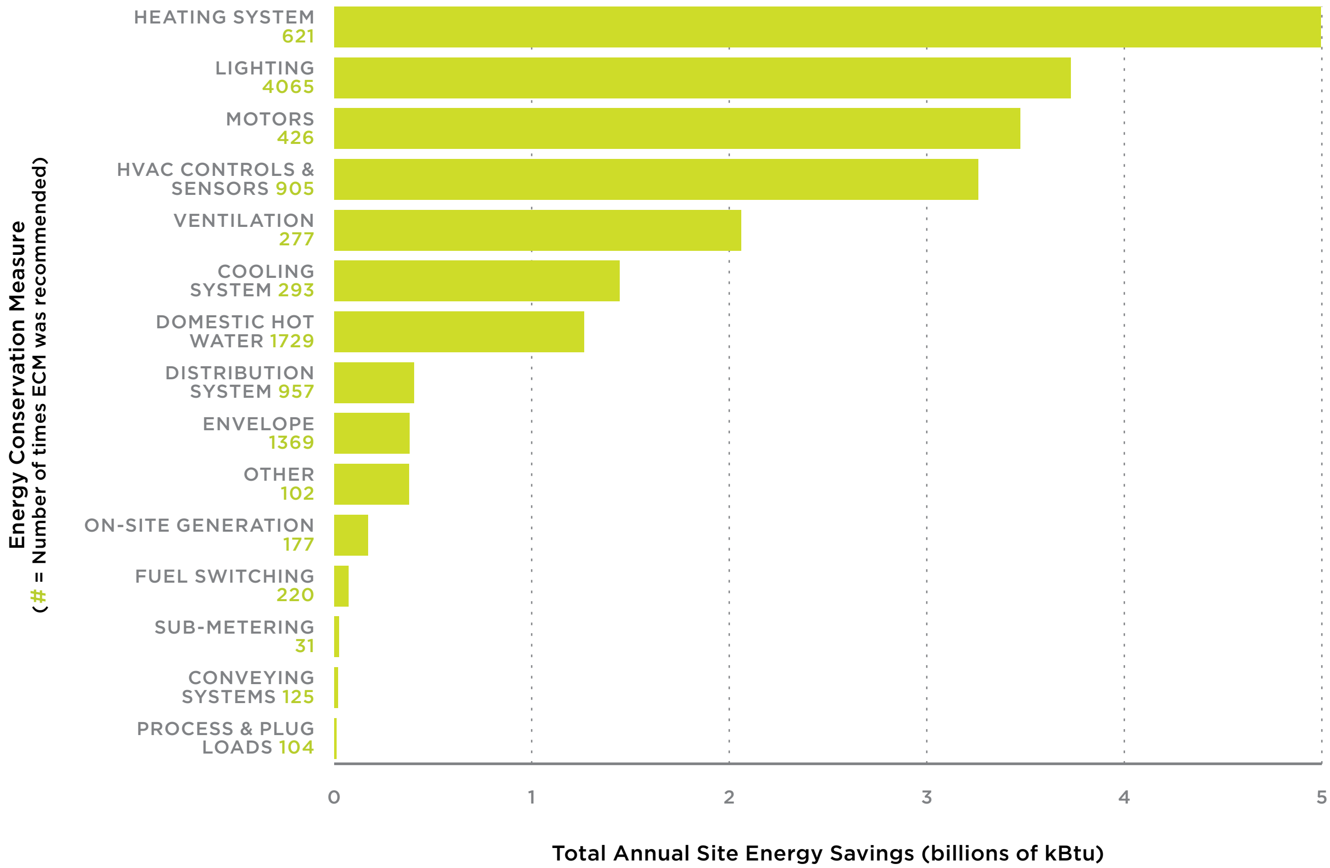
The results presented above should not be applied to any particular building. Instead, they can and should be used as an indication of what might happen, citywide, if these recommended measures were pursued, and as a guide to government and private utility program planners for areas that should receive early attention.

[38] Deutsche Bank CSR, Living Cities, HR&A Advisors, & Steven Winter Associates. (2012). The Benefits of Energy Efficiency in Multifamily Affordable Housing. Retrieved from http://energyefficiencyforall.org/sites/default/files/DBLC_Recognizing_the_Benefits_of_Efficiency_Part_B_1.10%20%281%29.pdf

[39] SF Environment & ULI Greenprint Center for Building Performance. San Francisco Existing Commercial Buildings Performance Report 2010-2014. Retrieved from http://sfenvironment.org/sites/default/files/fliers/files/sfe_gb_ecb_performancereport.pdf

Figure 20: Estimated Site Energy Savings for Each Energy Conservation Measure (LL87 data)

If implemented in their entirety, these measures could save 22 billion kBtu per year. (NYU CUSP)



RECOMMENDED ENERGY CONSERVATION MEASURES THAT OFFER THE MOST BENEFITS

When energy savings were analyzed on a floor area basis, the audit reports show that audited offices could realize the greatest savings from upgrades to ventilation systems, heating systems, and the installation of on-site generation, such as cogeneration and solar photovoltaics (Figure 21). (This type of on-site generation can be difficult to employ because of cost and physical limitations, such as limited, unshaded roof space.) Auditors suggested on-site generation for only nine audited office buildings in total. The audited office buildings that received suggestions to install solar photovoltaic systems averaged eight stories tall and had an average roof size of 15,000 square feet.

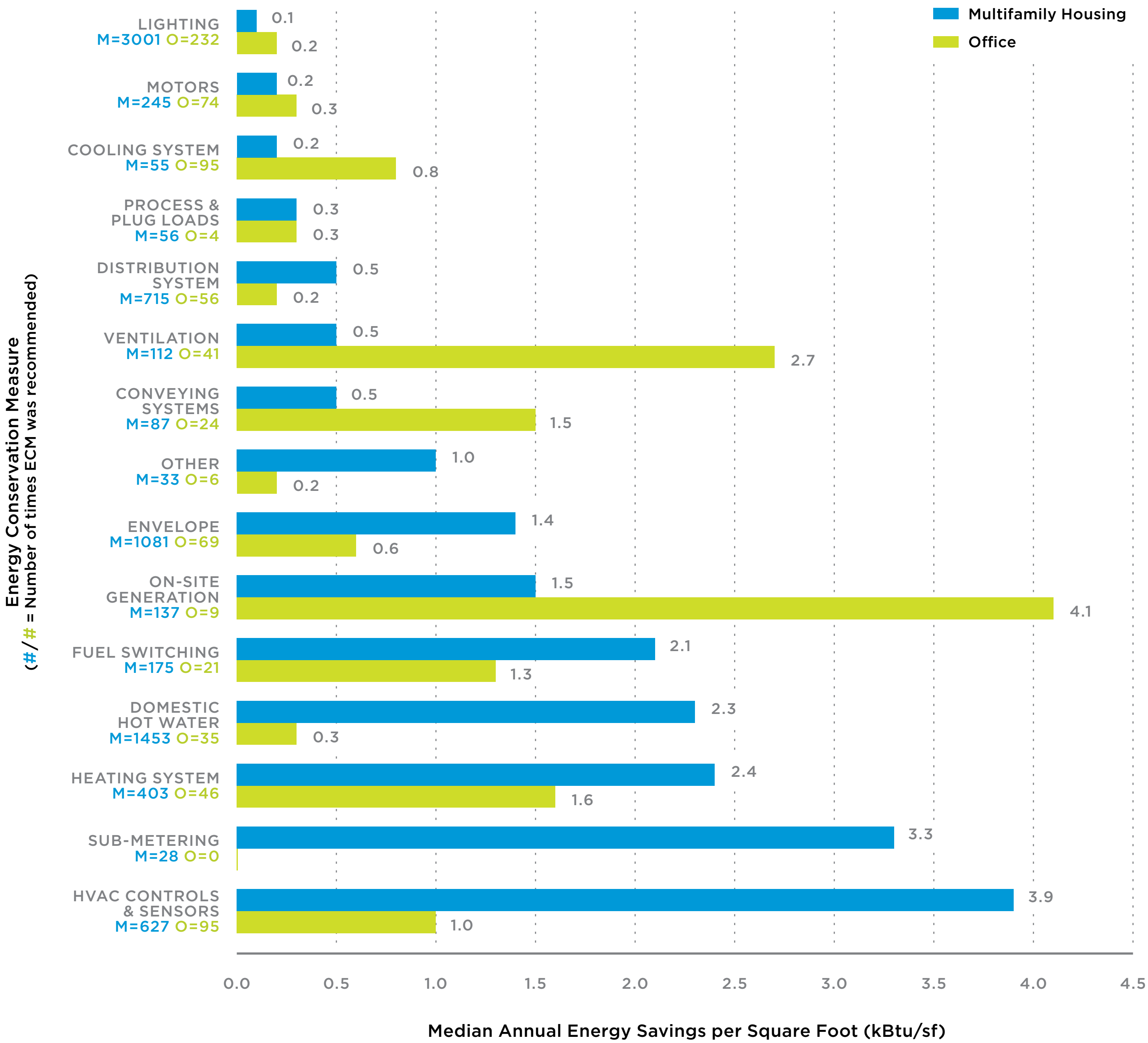
For audited multifamily properties, the greatest savings were expected to come from upgrades to HVAC controls and sensors, sub-metering, and heating systems.

SIMPLE PAYBACK PERIODS FOR RECOMMENDED ECMS

Many of the ECM categories show a median simple payback period of fewer than five years (Figure 22). The simple payback period shown above represents the sum of the capital costs of measures recommended in each category divided by the sum of the expected annual savings, and is not directly comparable to any individual ECM. It serves as a rough assessment[40] of an ECM's economic value but

Figure 21: Estimated Site Energy Savings per Square Foot for Each Energy Conservation Measure (LL87 data)

Audited offices could realize the greatest savings per square foot from on-site generation and ventilation, while audited multifamily buildings' greatest savings could come from HVAC controls. (NYU CUSP)

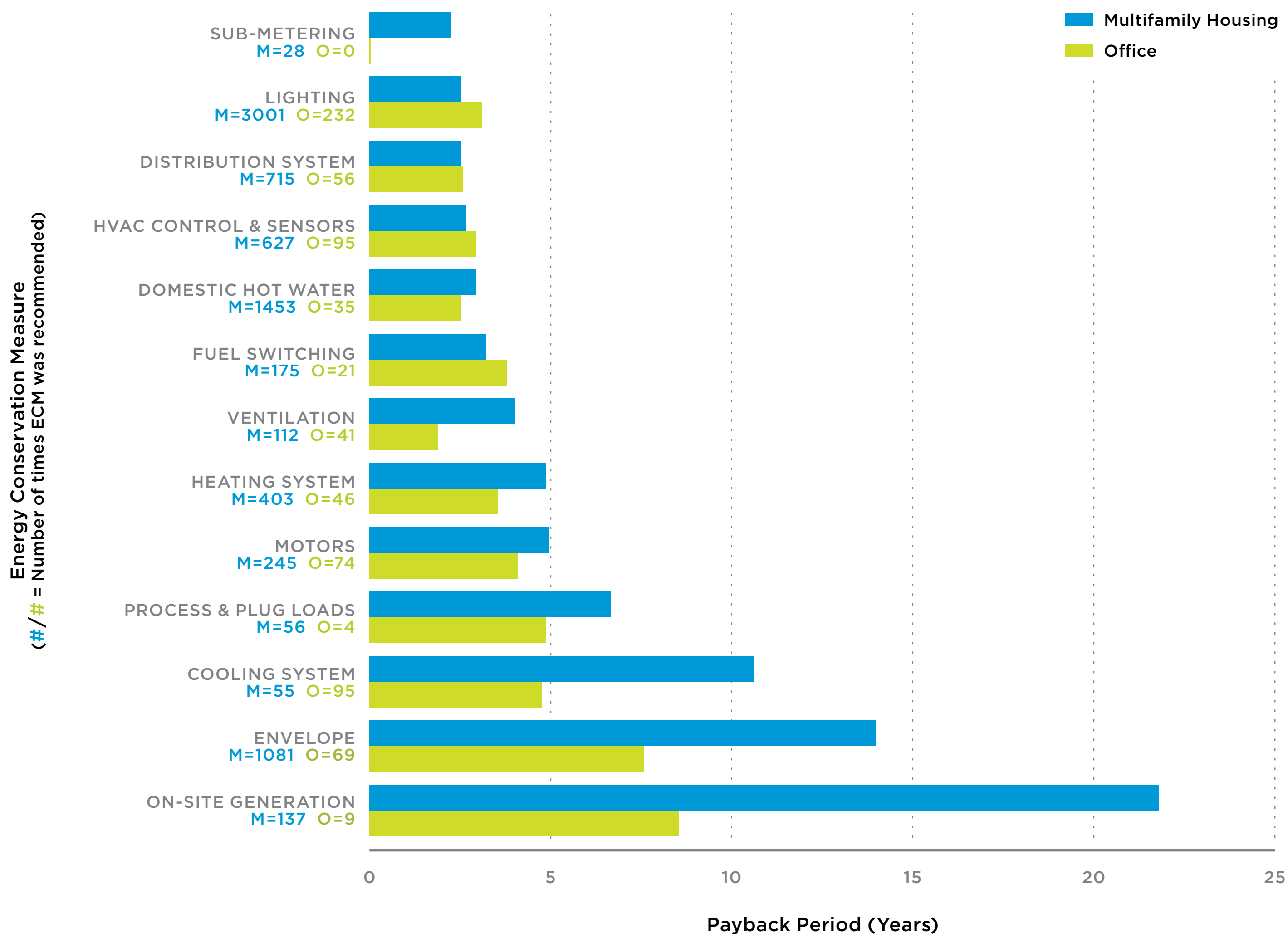


is not influenced by the expected life of the ECM, financing and other business requirements, expected changes in ownership, confidence in ECM cost- and energy-saving projections, and other factors. This data, like other data reported here, may be of more value to government and private utility program planners than to building operators, although it does offer a general guide to areas that offer the quickest return on investment.

[40] Deutsche Bank/Living Cities, HR&A Advisors, & Steven Winter Associates. (2011). Deutsche Bank/Living Cities: Building Energy Efficiency Data Report. Retrieved from www.swinter.com/8fbf625d-309f-4d7c-ba33-a390399aec68/resources-research-guidelines-research.htm

Figure 22: Median Simple Payback Periods for Each Energy Conservation Measure (LL87 data)

Many Energy Conservation Measure (ECM) categories display median simple payback periods of fewer than five years. (NYU CUSP)



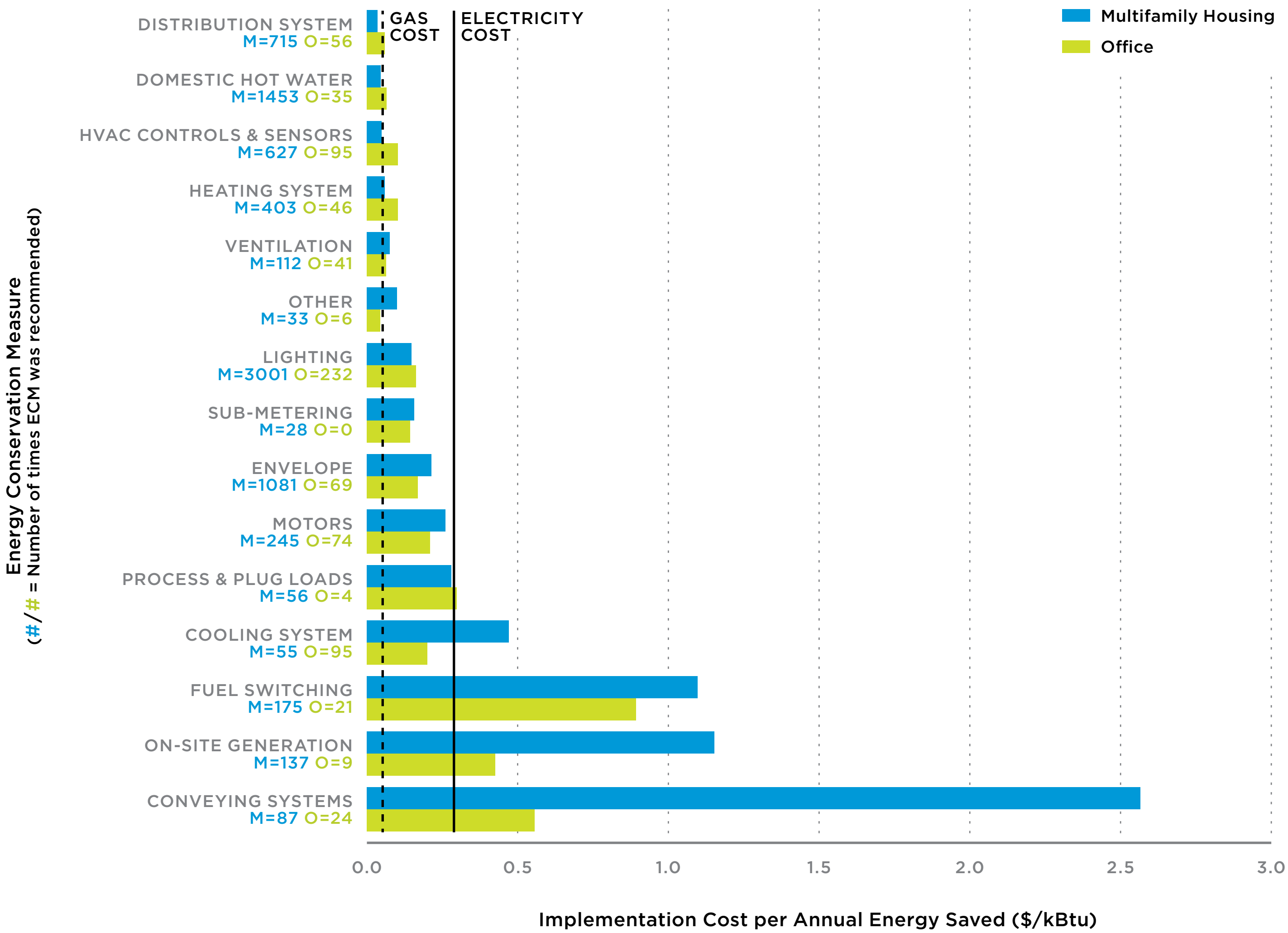
COMPARING THE FINANCIAL BENEFITS OF ECMS THAT SAVE ELECTRICITY WITH THOSE THAT SAVE NATURAL GAS

At current prices, ECMs that save electricity are financially more attractive than those that save fuel. This is indicated in Figure 23, in which the vertical bars represent the break-even cost per kBtu of gas (dashed vertical black line) and electricity (solid vertical black line) for a five-year payback.[41] That is, ECMs that save electricity and have a cost to the left of the solid vertical black line, such as those for process and plug loads or lighting, are likely to pay for themselves in five or fewer years. Similarly, measure categories that save gas and for which the bar ends to the left of the dashed vertical black line are likely to have a payback of five or fewer years, as, for example, with distribution system measures in offices.

[41] At $1.00 per therm of gas and $0.20 per kWh of electricity, the breakeven cost for a five-year payback is $0.05/kBtu for gas and $0.29/kBtu for electricity: New York State Energy Research and Development Authority (NYSERDA). Energy Prices and Weather Data. Retrieved from https://www.nyserda.ny.gov/Cleantech-and-Innovation/Energy-Prices

Figure 23: Cost per Amount of Energy Saved for Each Energy Conservation Measure (LL87 data)

At current prices, Energy Conservation Measures (ECMs) that save electricity are more financially attractive than those that save natural gas. (NYU CUSP)



The fact that only a small number of ECM categories achieve the break-even point for natural gas savings is the result of current, low natural gas prices.[42] Residential gas prices are no higher than prices in 1980 if the cost comparison is adjusted for inflation. As with all measures, some of the ECMs will be more energy and cost-effective than the category average, and some will be less. The values displayed are general summaries over several ECMs; individual buildings will require analyses of their options.

[42] U.S. Energy Information Administration. (2016). Natural Gas Prices. Retrieved from https://www.eia.gov/dnav/ng/ng_pri_sum_dcu_nus_m.htm

YEAR FOUR BENCHMARKING DATA RESULTS

This report analyzes not only LL87 data but also the most recently available benchmarking data at the time this analysis was undertaken—data collected by the City under LL84 in 2014 for energy and water consumed during 2013. As the number of buildings reporting increases and the quality of the data improves each year, benchmarking better represents the energy and water consumption of New York City's largest buildings.[43] This fourth year of data, once cleaned, continues to demonstrate previous trends and to highlight paths that can help the City reduce energy and water use in its largest buildings.

BUILDING CHARACTERISTICS

Buildings reporting in 2014 were grouped into one of three categories: multifamily, office, and "Other." These building classifications are drawn from those that property owners selected on Portfolio Manager as part of the benchmarking reporting process As noted in previous years, the majority of New York City's floor area is comprised of multifamily properties, at 67 percent, followed by office properties, at 24 percent (Figure 24). Within the "Other" category, non-refrigerated warehouses and senior care communities were among the largest property types reported (Figure 25).

Figure 24: Floor Area by Sector (LL84 data)
Multifamily buildings comprise the majority of benchmarked buildings. (Urban Green Council)

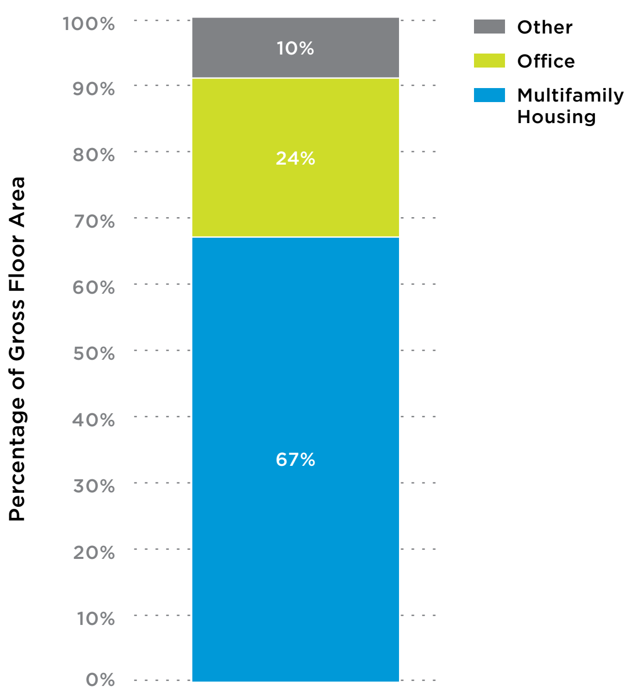
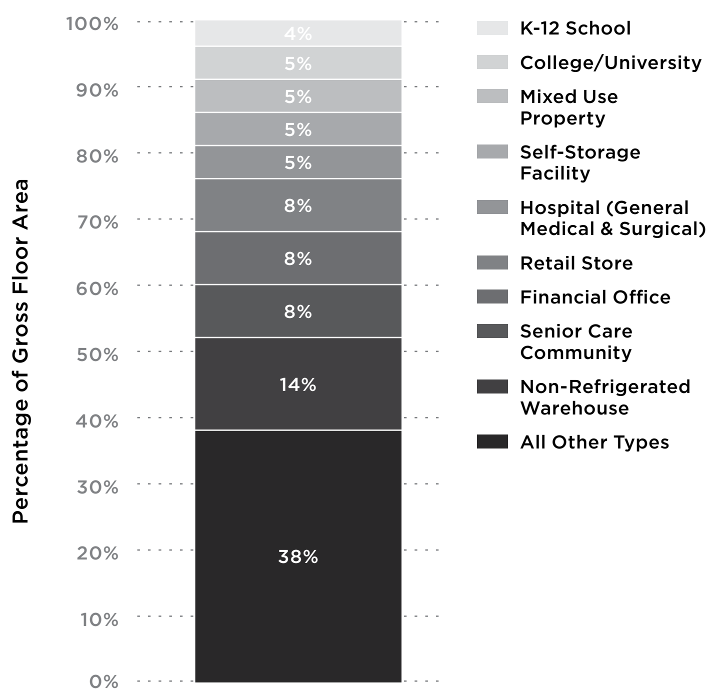


Figure 25: Floor Area Breakdown of "Other" Sector (LL84 data)
Hospitals and senior care communities are the top benchmarked building categories designated as "Other." (Urban Green Council)



[43] For further details on compliance metrics, see Appendix B.

SIZE

The majority of benchmarked multifamily and office properties have a floor area between 50,000 square feet, which is the benchmarking minimum, and 100,000 square feet (Figure 26). This is particularly true for multifamily buildings. More than half of these properties are smaller than 100,000 square feet. Office buildings, by contrast, are often very large, with more than one in three office buildings occupying more than 300,000 square feet. (Fewer than one in 12 multifamily buildings encompass 300,000 square feet.) Additionally, almost 10 percent of office properties encompass floor areas greater than 1,000,000 square feet.

Figure 26: Number of Benchmarked Properties by Gross Floor Area (LL84 data)
Most benchmarked buildings are smaller than 100,000 square feet. (NYU CUSP)

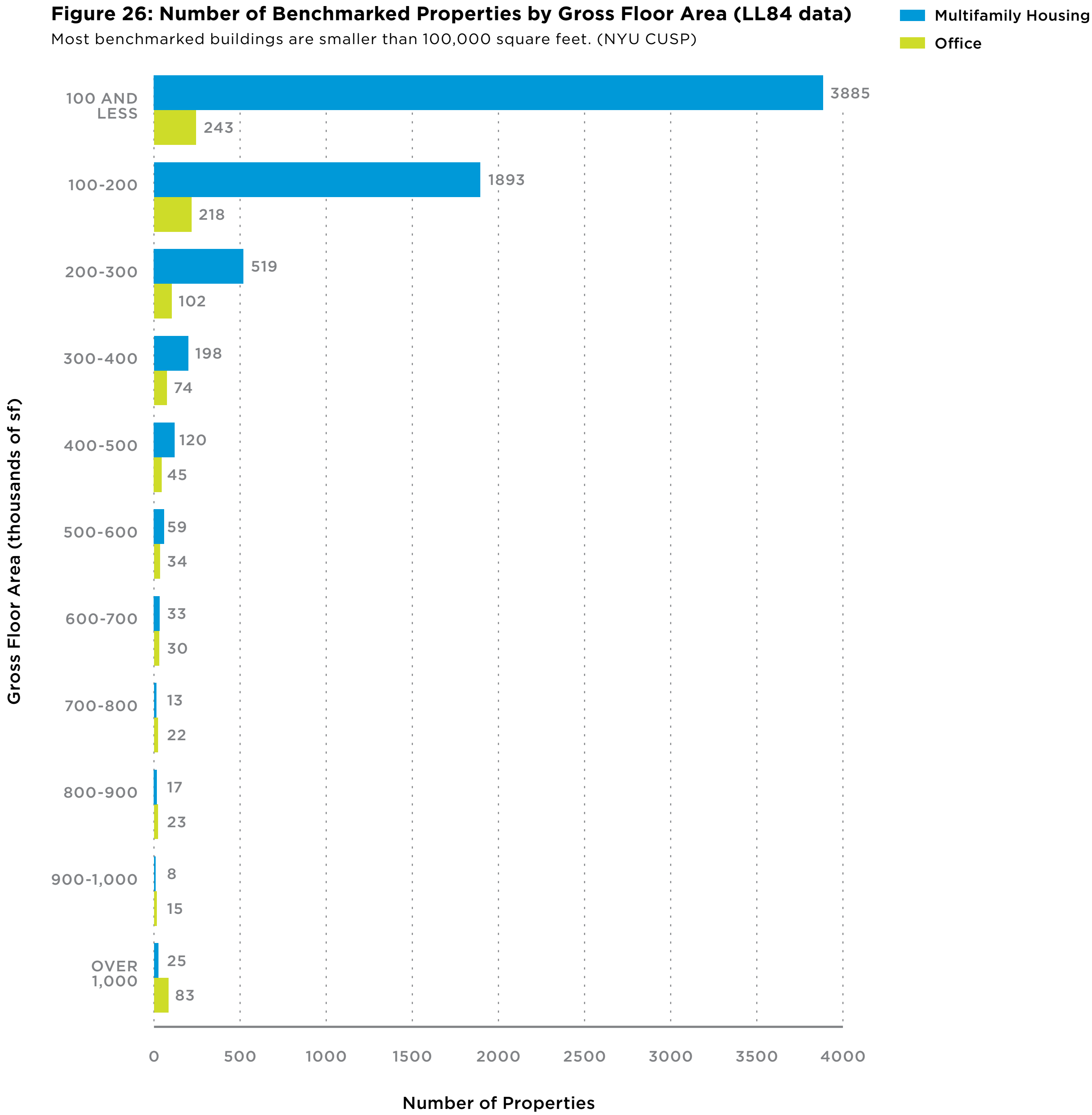
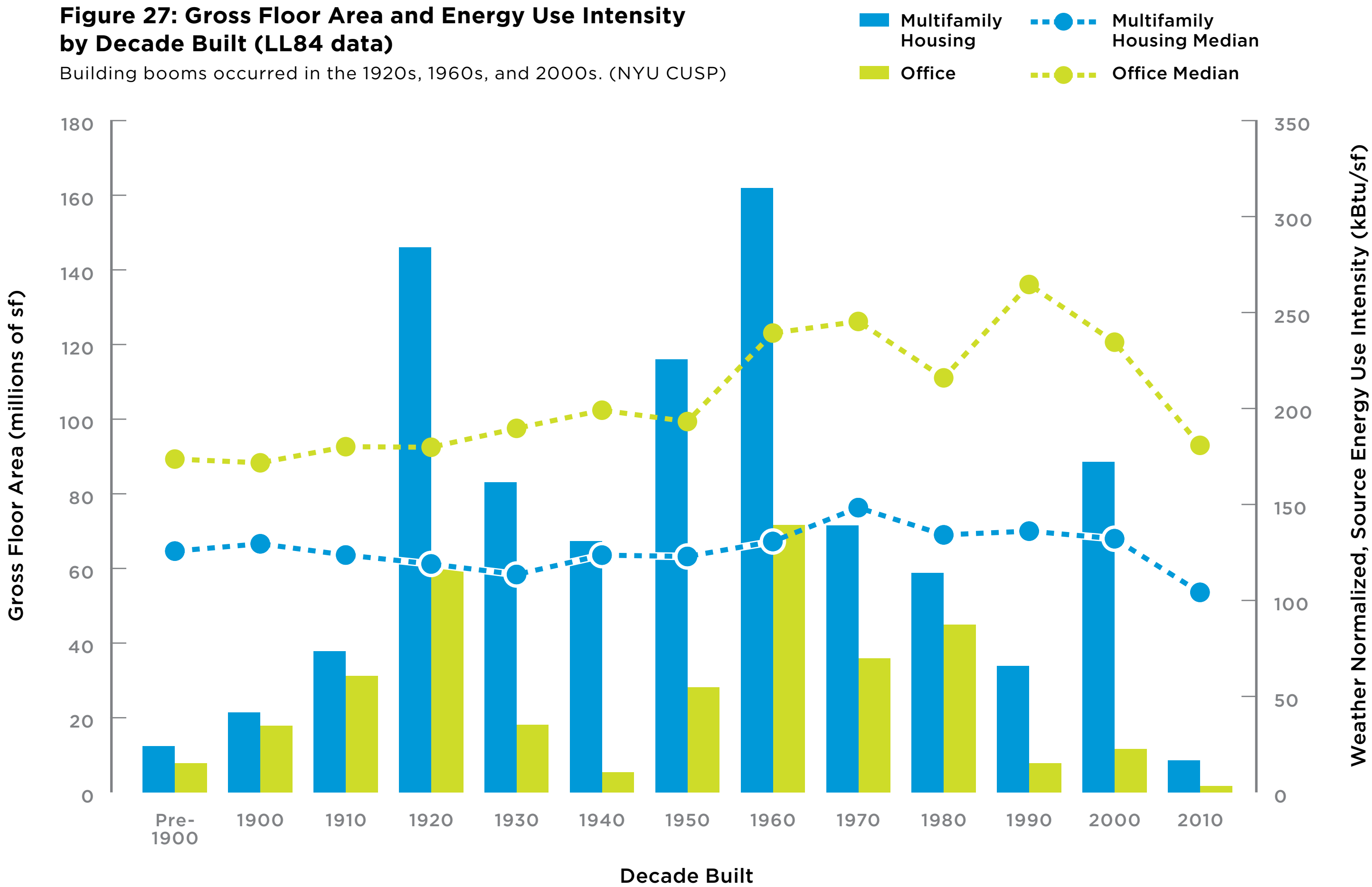


Figure 27: Gross Floor Area and Energy Use Intensity by Decade Built (LL84 data)

Building booms occurred in the 1920s, 1960s, and 2000s. (NYU CUSP)



AGE

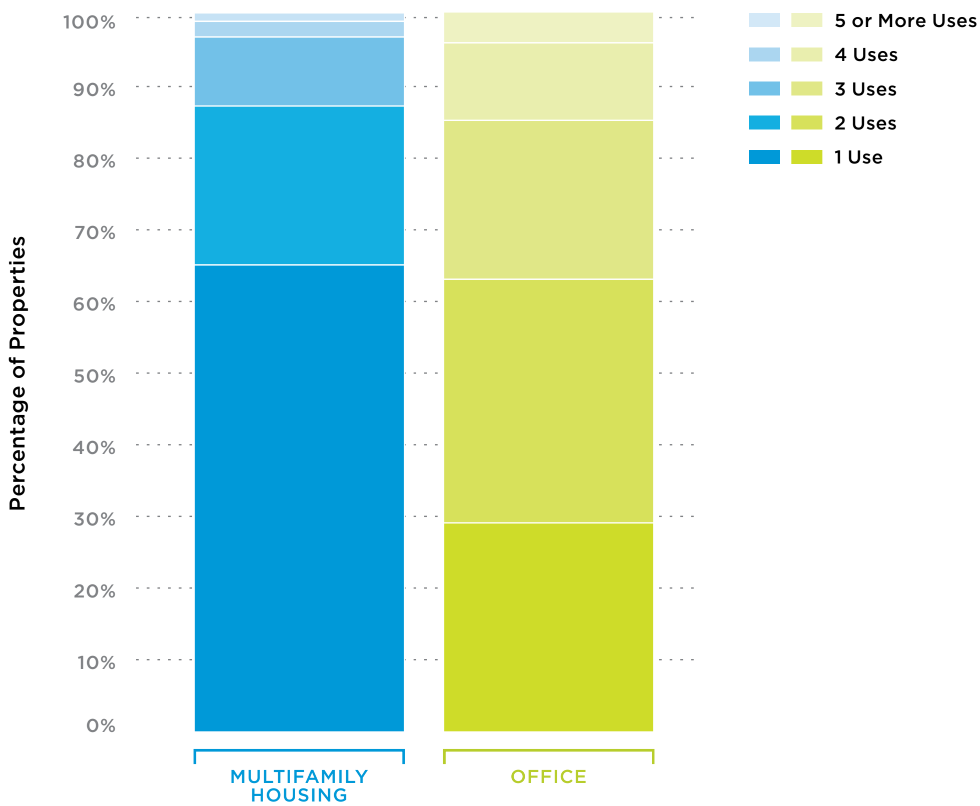
A building's age is often a useful indicator of its energy use, as shown in Section 5. To that end, construction trends help show when much of New York City's benchmarked building stock was built. For example, both the office and multifamily building sectors experienced booms in the 1920s and 1950s-60s (Figure 27). More recently, in the 2000s, multifamily construction has been the primary driver of growth in floor area and number of buildings. Multifamily and office properties built in the 1960s and 1970s also appear to be larger than those built earlier in the 1920s. Though a similar amount of floor area was built during both eras, the number of buildings built in the 1960s and 1970s is nearly half that built in the 1920s.

BUILDING USE

Another common characteristic of some New York City buildings that can impact energy use is mixed building use. For example, some multifamily buildings include retail stores or banks on the first floor, while offices and industrial spaces sometimes share buildings. In 2013, owners of nearly 75 percent of multifamily buildings and 40 percent of office buildings reported their buildings were single-use (Figure 28). And though some large buildings housed as many as five or more uses, the majority of the remainder were only used for one additional purpose.

Figure 28: Number of Property Uses (LL84 data)

More than half of benchmarked offices and nearly a quarter of benchmarked multifamily buildings also serve at least one other purpose. (NYU CUSP)



ENERGY USE BY THE BUILDING SECTOR IN 2013

As noted above, multifamily and office properties are the most represented in the benchmarked dataset. Together, these sectors consume a full 87 percent of the total benchmarked source energy (Figure 29). The office sector is the more energy intensive of the two, using 56 percent more energy per square foot than the multifamily building sector. The office median source EUI was 195 kBtu/sf; that for multifamily buildings was 125 kBtu/sf. The higher electricity load for cooling, lighting, and appliances in office buildings likely explains much of the difference (Figure 3).

Neither of these sectors is the most energy intensive. Supermarkets and hospitals are, using nearly two-and-a-half times more energy per square foot than offices and four times more than multifamily buildings. However, because supermarkets and hospitals represent a much smaller fraction of total, citywide energy consumption, the multifamily and office sectors remain, appropriately, the major focus of City efforts.

Figure 29: Median Energy Use Intensity by Property Type (LL84 data)

(area of circle is proportional to energy consumed). Benchmarked multifamily buildings consume the most energy overall, while benchmarked supermarkets use the most energy per square foot. (NYU CUSP)

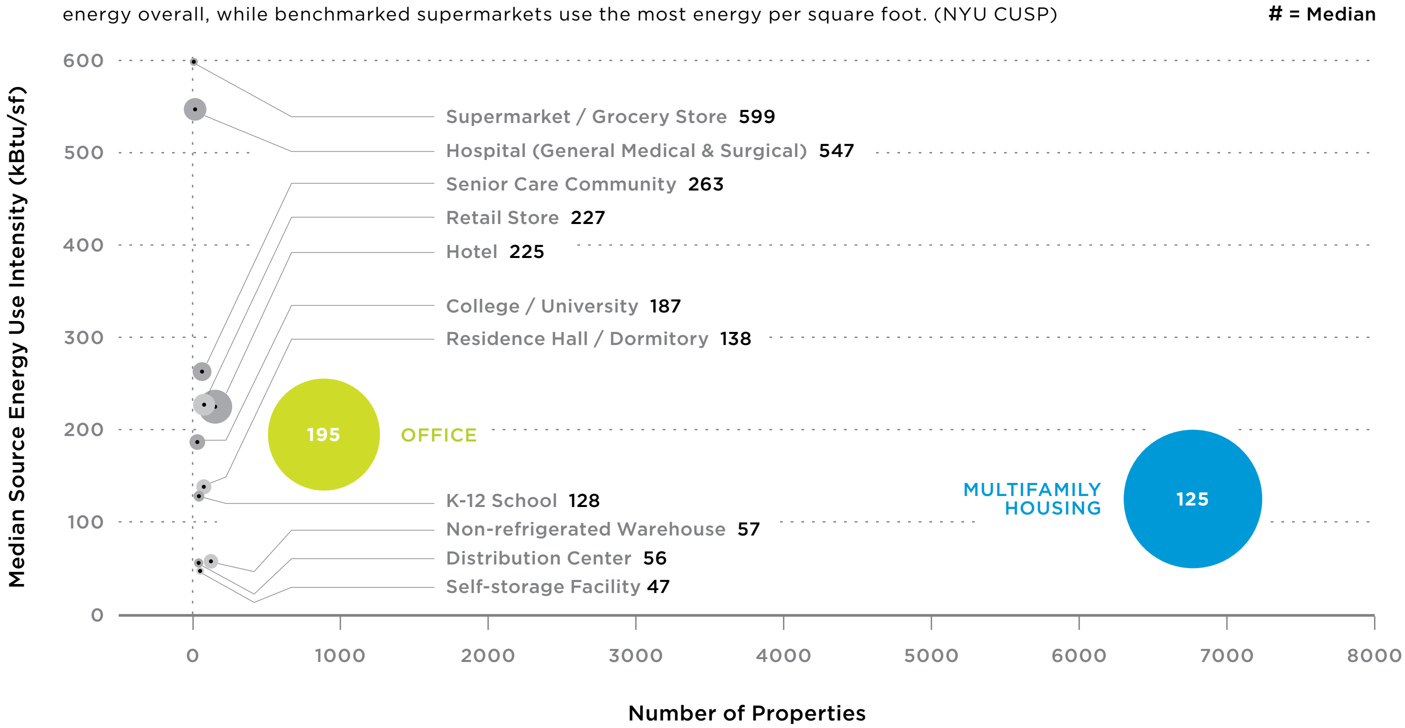


Figure 30: Distribution of Source Energy Use Intensity Scores for Benchmarked Multifamily and Office Properties (LL84 data)

Large offices tend to be more energy intensive than large multifamily properties. (NYU CUSP)

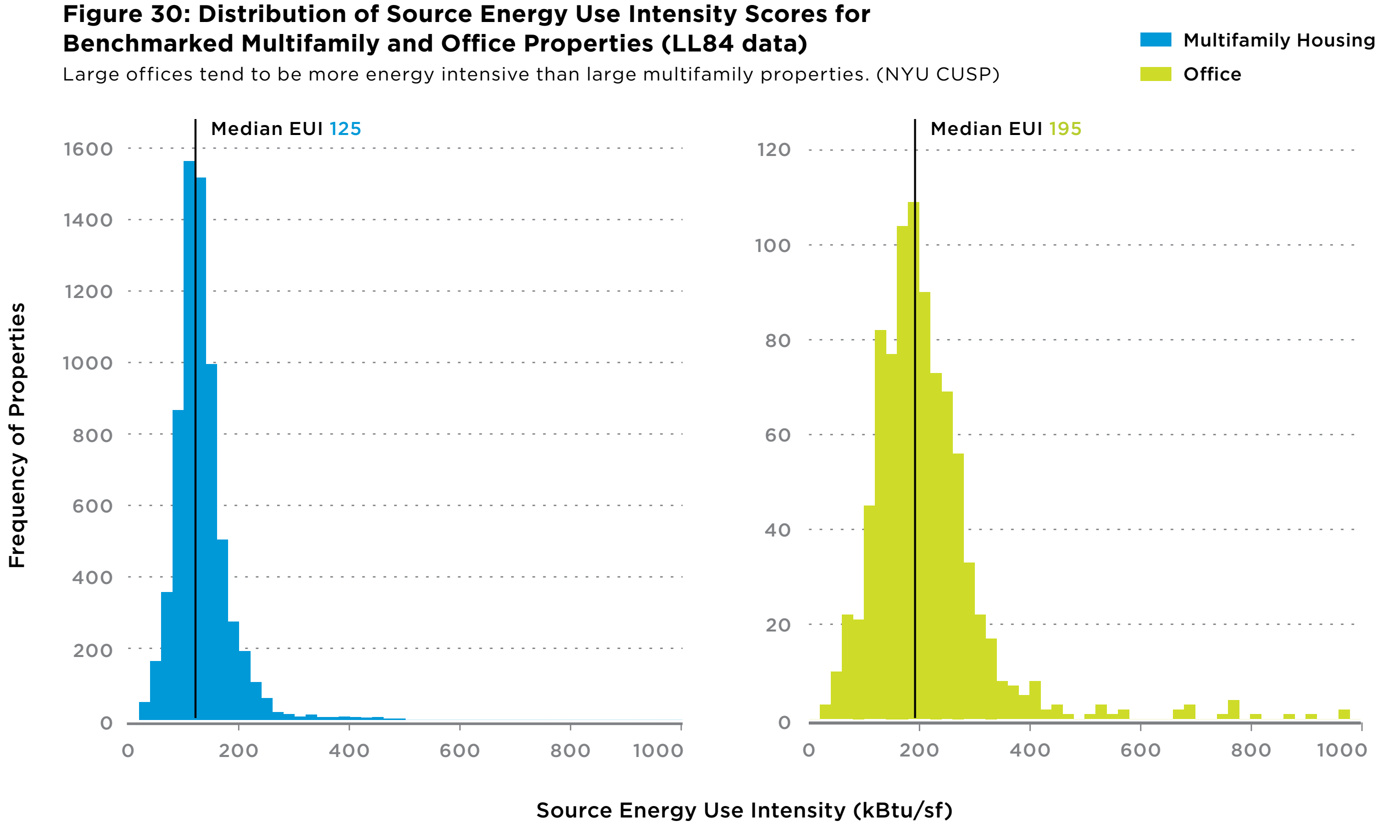
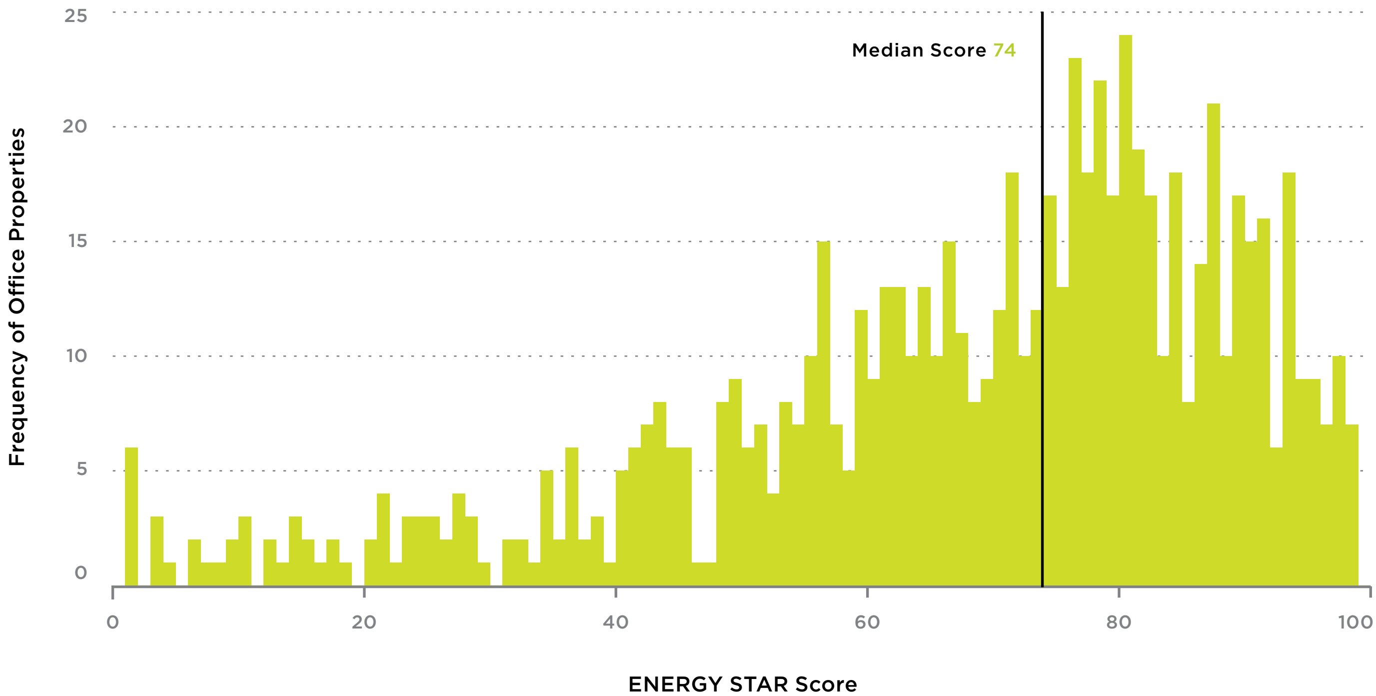


Figure 31: Distribution of New York City 2013 Office ENERGY STAR Scores (LL84 data)

New York City's median ENERGY STAR score, 74, surpasses the national median of 50. (NYU CUSP)

Percentage of Offices Reporting: 84%



HOW NEW YORK CITY MEASURES UP TO OTHER CITIES

New York City's multifamily and office properties perform similarly to those in other peer cities. The U.S. Energy Information Administration (EIA) conducts two national surveys of both commercial and residential building stock, energy consumption, and energy expenditure, known, respectively, as the Commercial Building Energy Consumption Survey (CBECS) and the Residential Energy Consumption Survey (RECS). They serve as useful benchmarks for building energy use. Compared to offices sampled in CBECS, and without controlling for type of tenancy, New York City's office buildings, with a source EUI of 195 kBtu/sf, use 8 percent more source energy per square foot.[44] Meanwhile, New York City's multifamily buildings' median site EUI, 85 kBtu/sf, is about 11 percent higher than that found in the Northeast overall.[45] Given that New York City's buildings are more densely occupied and used, their energy use intensities are expected to be slightly higher than those of their peers.

This remains true when considering how New York City's ENERGY STAR scores stack up against those of the rest of the country. For 2013, this comparison was limited to office buildings and further narrowed to the 747 properties receiving scores.[46] The city's median ENERGY STAR score of 74 suggests that it is

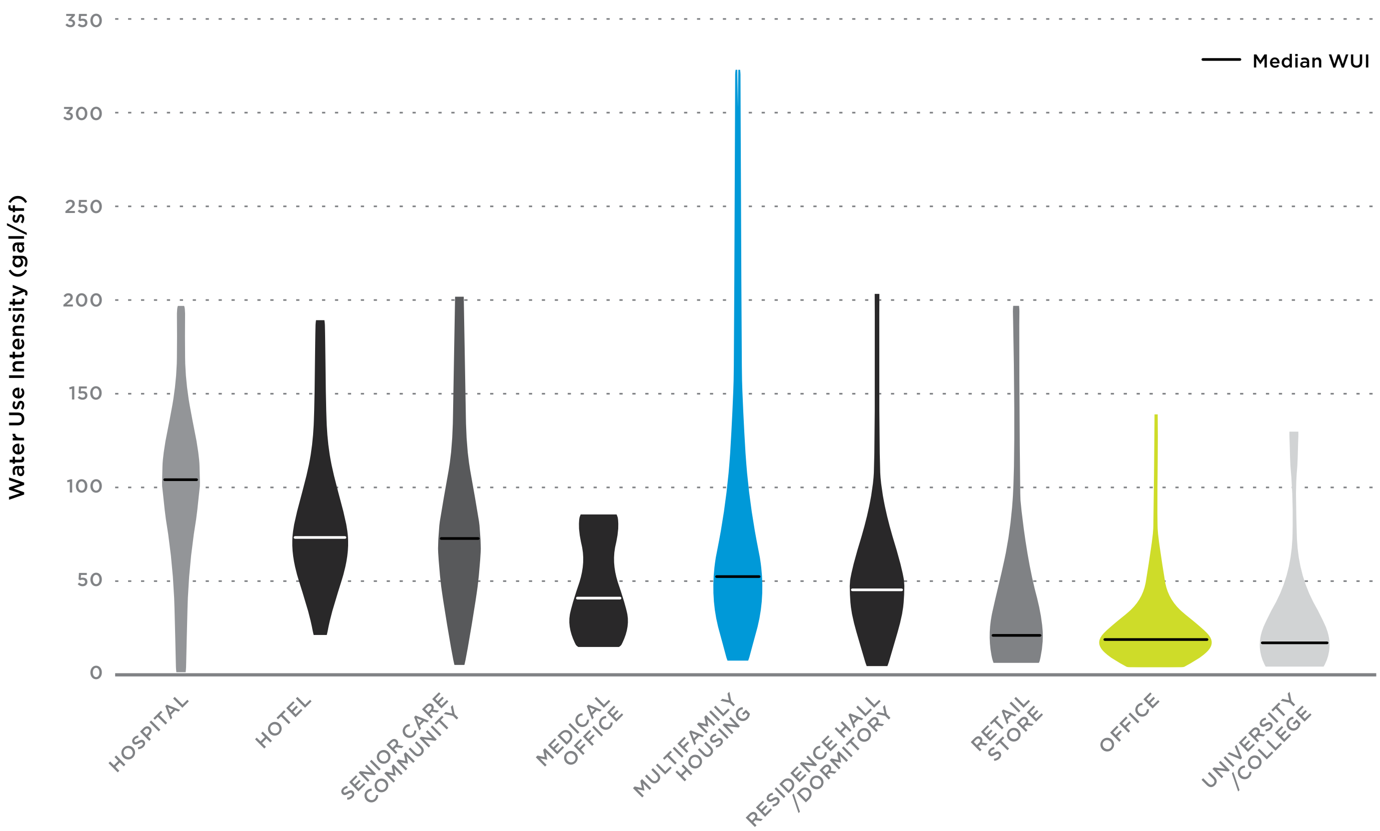
[44] U.S. Energy Information Administration. Commercial Buildings Energy Consumption Survey (CBECS). Retrieved from www.eia.gov/consumption/commercial/

[45] U.S. Energy Information Administration. (2009). Residential Energy Consumption Survey (RECS). Retrieved from www.eia.gov/consumption/residential/

[46] ENERGY STAR scores for multifamily properties will be reported in the 2014 New York City benchmarking data and will significantly increase the number of properties that receive ENERGY STAR scores: U.S. Environmental Protection Agency. ENERGY STAR Score for Multifamily Housing in the United States. Retrieved from https://www.energystar.gov/buildings/tools-and-resources/energy_star_score_multifamily_housing_united_states.

Figure 32: Distribution of Water Use Intensity by Benchmarked Property Type (LL84 data) [50]

The hospital sector is the most water intensive, while the multifamily sector is the largest user of water overall. (Urban Green Council)



performing well above the national median of 50 (Figure 31). New York City has a lower median score than other major cities such as San Francisco (87), Washington, D.C. (79), and Boston (78), though its median score is higher than Philadelphia's (64).[47] It is possible that the methodology that ENERGY STAR uses to calculate this score does not account for New York City's unique building size and density. Therefore ENERGY STAR has potential limitations in predicting building energy use in New York City.[48]

WATER USE IN 2013

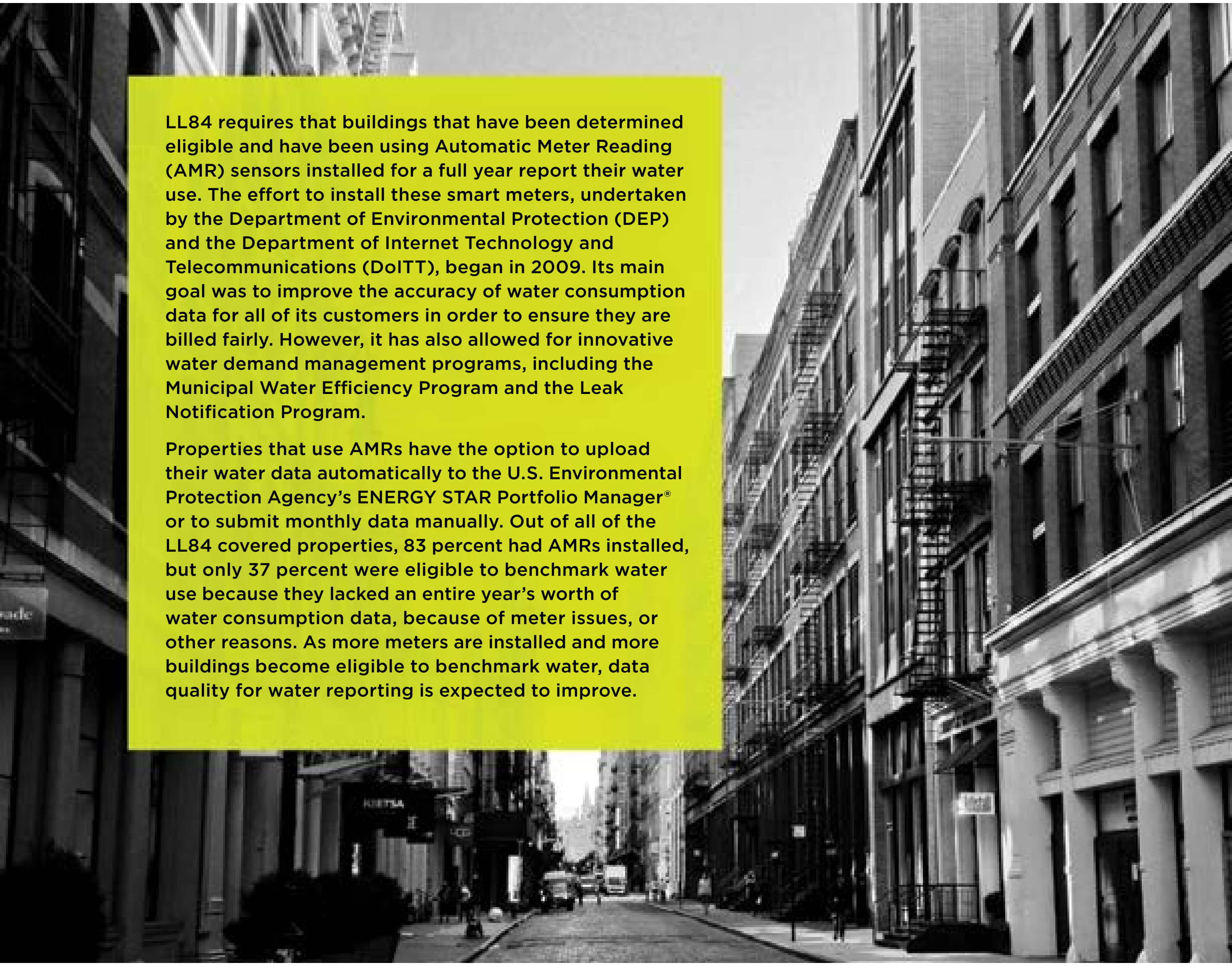
In 2013, the buildings represented in Figure 32, below, used 21 billion gallons of water, enough to fill the Central Park Reservoir 20 times over.[49] While hospitals and hotels used water most intensively, multifamily and office properties comprised 90 percent of this water use, due to their prevalence in the dataset.

[47] SF Environment & ULI Greenprint Center for Building Performance. San Francisco Existing Commercial Buildings Performance Report 2010-2014. Retrieved from http://sfenvironment.org/sites/default/files/fliers/files/sfe_gb_ecb_performancereport.pdf. Greenovate Boston. (2015). Energy and Water Use in Boston's Large Buildings, 2013Retrieved from http://www.cityofboston.gov/images_documents/BERDO_rprt_webfinal_tcm3-52025.pdf

[48] Kontokosta, C. E. (2014). A Market-Specific Methodology for a Commercial Building Energy Performance Index. The Journal of Real Estate Finance and Economics J Real Estate Finan Econ, 51(2), 288-316. Retrieved from http://link.springer.com/article/10.1007/s11146-014-9481-0

[49] Greensward Group, LLC. Reservoir. Retrieved from www.centralpark.com/guide/attractions/reservoir.html

[50] The width of each violin plot approximates the number of properties with that water use intensity in that sector.



LL84 requires that buildings that have been determined eligible and have been using Automatic Meter Reading (AMR) sensors installed for a full year report their water use. The effort to install these smart meters, undertaken by the Department of Environmental Protection (DEP) and the Department of Internet Technology and Telecommunications (DoITT), began in 2009. Its main goal was to improve the accuracy of water consumption data for all of its customers in order to ensure they are billed fairly. However, it has also allowed for innovative water demand management programs, including the Municipal Water Efficiency Program and the Leak Notification Program.

Properties that use AMRs have the option to upload their water data automatically to the U.S. Environmental Protection Agency's ENERGY STAR Portfolio Manager® or to submit monthly data manually. Out of all of the LL84 covered properties, 83 percent had AMRs installed, but only 37 percent were eligible to benchmark water use because they lacked an entire year's worth of water consumption data, because of meter issues, or other reasons. As more meters are installed and more buildings become eligible to benchmark water, data quality for water reporting is expected to improve.

Of the two largest water consumers, the multifamily sector should remain the focus for efforts to reduce potable water use. In addition to consuming almost eight times more water in total than office buildings, multifamily properties are also more water intensive, with a per-square-foot water footprint three times greater than that of office buildings. The multifamily sector also includes the most water-intensive benchmarked properties, as evidenced by the tall tail in Figure 32, below. Possible explanations for these large water users include operation and maintenance issues, building owners paying a flat rate for water and thus not being aware of their buildings' usage, or other causes.

HISTORICAL COMPARISONS

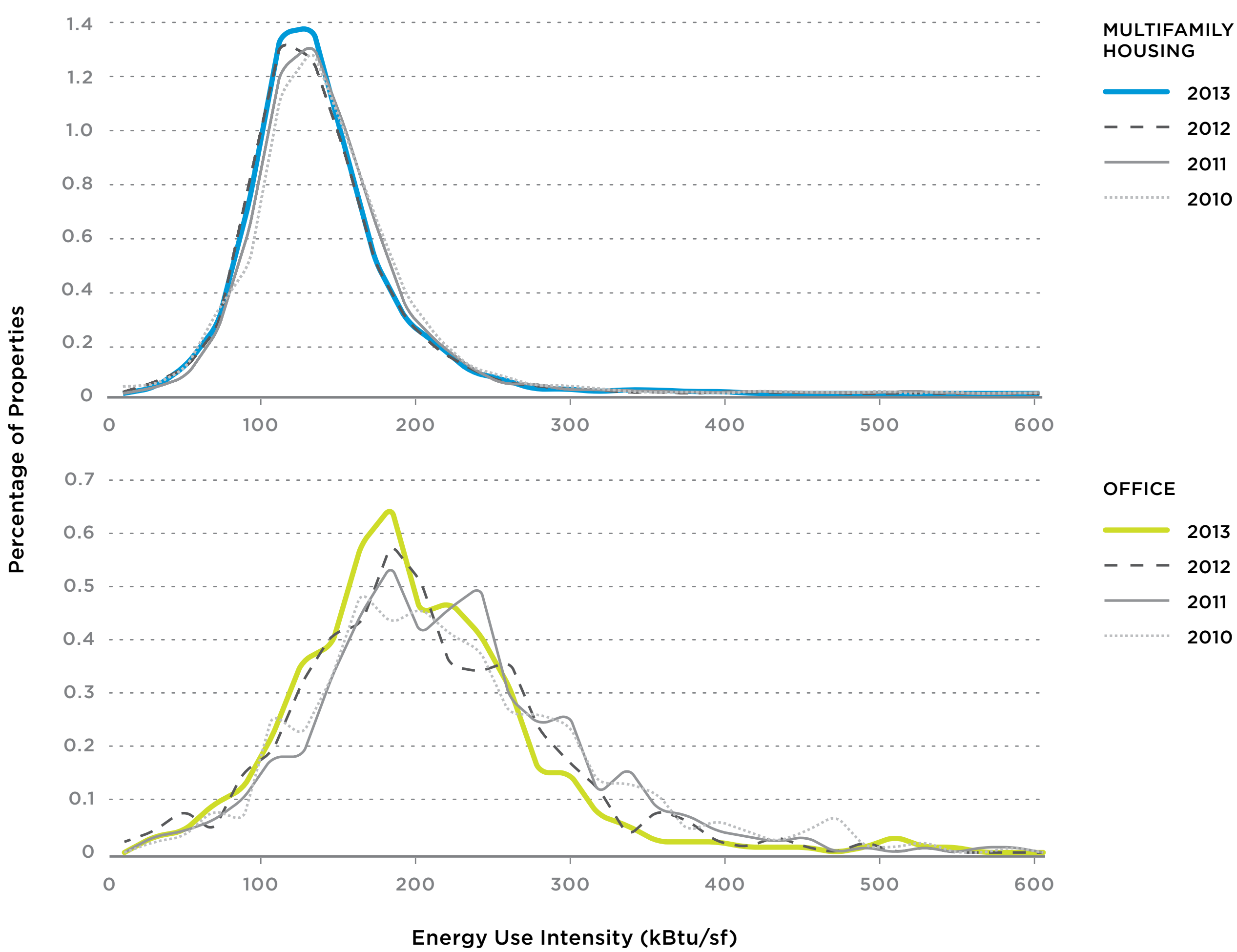
BENCHMARKED BUILDINGS' ENERGY USE HAS DECREASED OVER THE LAST FOUR YEARS

With each year of additional data, we develop a better understanding of how benchmarked properties use energy over time. Buildings that have benchmarked in each of the four years covered in this report have reduced emissions by 8 percent. These declines show encouraging progress toward the City's carbon reduction goals, although considerable work remains.

Analysis of the two largest sectors shows differences in reductions over time. Over the four years data has been collected, there has been a slight decrease

Figure 33: Energy Use Intensity Distribution of Benchmarked Properties Reporting in All Four Years (LL84 data)

Since benchmarking began in 2010, office properties have shown larger reductions in energy use than multifamily properties have. (NYU CUSP)



in multifamily energy use, but the majority of the properties are still within the same range of EUIs they first reported in 2010 (Figure 33). By contrast, the distribution for office properties shows more significant reductions. The longer tail in the office distribution in Figure 33, below, indicates that there are buildings with higher energy intensities that might result from longer operating hours, higher densities of workers or technology, or other causes. Yet even this tail is gradually flattening, suggesting that high users of energy have also been reducing their energy use.

Overall energy use for these sectors illustrates these trends more clearly (Figure 34). The median energy use intensity for multifamily properties has dropped 5 percent over four years, while the median for offices has dropped by 11 percent. In 2013, the median ENERGY STAR score for offices reporting consistently in all four years was 78, four points higher than the score for office properties reporting only in 2013 (Figure 31). This represents a 12 percent increase from their 2010 median score and shows that half of the consistently reporting office buildings qualified for ENERGY STAR certification, which requires a score of 75 or above.

In addition to more permanent improvements such as operator training and ECMs, temporary factors could have contributed to this reduction in energy use. The most notable was Superstorm Sandy in late October of 2012, which caused many buildings in the inundation areas to be unoccupied for periods of time. Among benchmarked properties, this had a greater impact on office properties and may partially account for the greater reductions seen in that sector. An analysis in the previous benchmarking report that looked at a

Figure 34: Median Weather Normalized, Source Energy Use Intensity by Data Year for Consistently Benchmarked Properties (LL84 data)

Overall, the energy use intensities of office and multifamily properties reporting in all four years have decreased. (NYU CUSP)

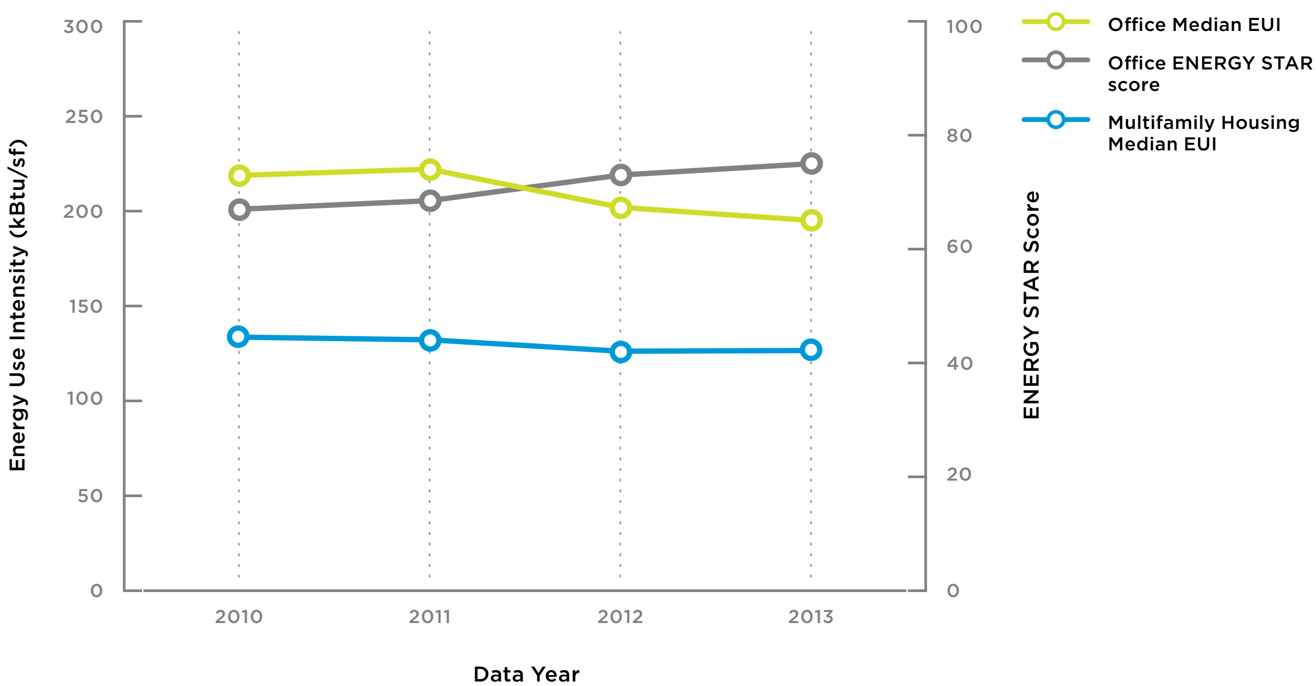
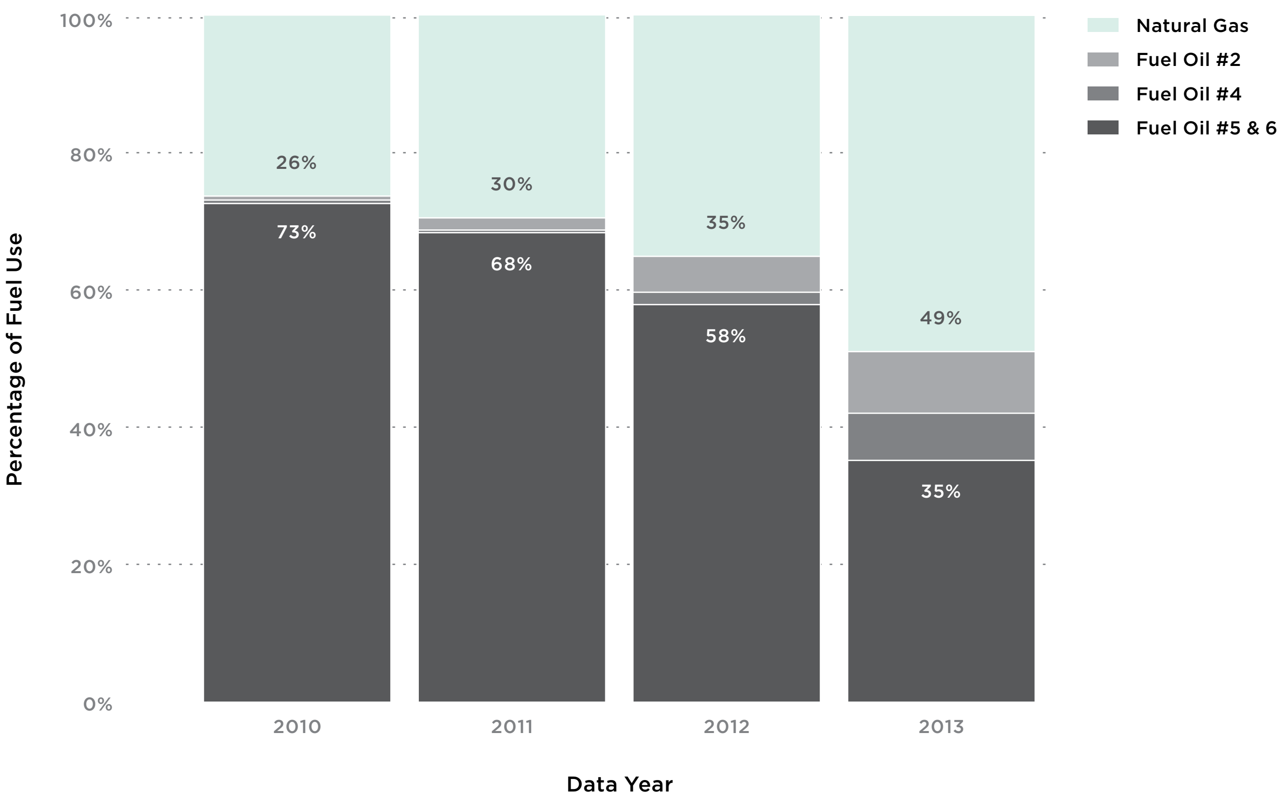


Figure 35: Fuel Composition of #6 Fuel Users (LL84 data)

Since 2010, properties that initially reported using New York's heaviest fuel, #6 oil, now use substantially less of it. (NYU CUSP)



small sample of properties located in the Sandy inundation zone showed that office and multifamily median EUIs had dropped by 26 percent and 5 percent, respectively, from 2011 to 2012.[51] Lingering effects from Sandy may be seen in the 2013 data, as some buildings were still undergoing repairs during this time. But further investigation is necessary to determine the impact.

The NYC Clean Heat program, which has now been incorporated into the NYC Retrofit Accelerator, is a major factor in the emissions reductions seen since 2010.[52] Until 2015, its focus had been to help building owners comply with DEP regulations that require buildings to convert from #6 fuel oil for heat and hot water to #2 fuel oil or natural gas. Due to this program's efforts, the use of #6 fuel oil, which generates 44 percent more CO_2 emissions per unit of energy (Btu) than natural gas, has dropped nearly 40 percent from 2010 to 2013 (Figure 35). As a result, natural gas and cleaner fuel oils have increased their share of the energy mix by 22 percent and 15 percent, respectively. This fuel switching will reduce emissions, but it will not have a large impact on buildings' energy use intensities since energy use will remain largely unchanged. DEP scheduled the complete phase out of #6 fuel oil for June 2015 and #4 oil for 2030, so these reductions should continue to be reflected in future emissions and fuel use data.[53] At present, however, it is difficult to separate the decline in emissions due to fuel switching from the decline in source energy use that results from improved efficiency.

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[51] The City of New York. (2014). New York City Local Law 84 Benchmarking Report, September 2014. Retrieved from www.nyc.gov/html/planyc/downloads/pdf/publications/2014_nyc_ll84_benchmarking_report.pdf

[52] For more information on the NYC Clean Heat Program and the NYC Retrofit Accelerator, visit the City's website: www.nyc.gov/retrofitaccelerator.

[53] New York City Mayor's Office of Sustainability. (2016). Heating Oil Regulations. Retrieved from http://www.nyc.gov/html/gbee/html/codes/heating.shtml

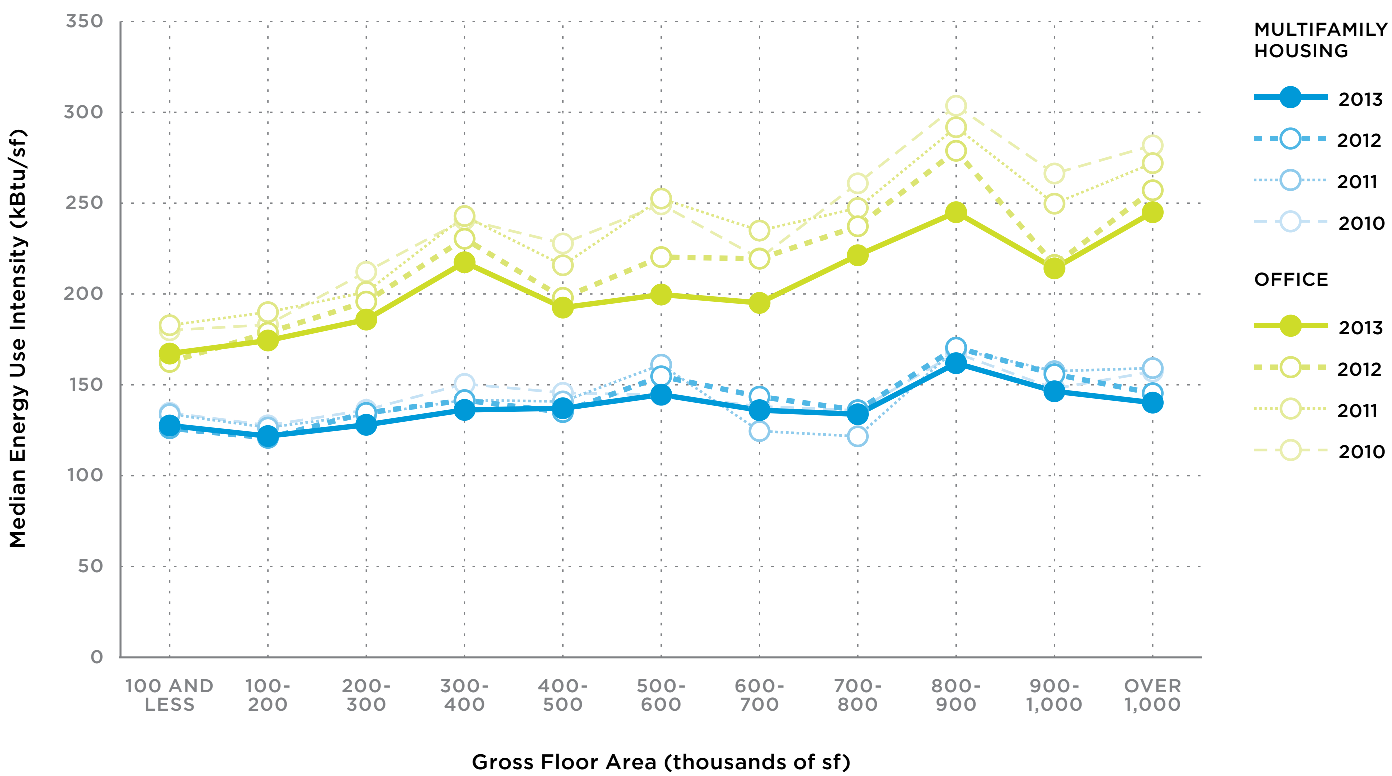
UNDERSTANDING THE RELATIONSHIP BETWEEN BUILDING AGE AND SIZE AND ENERGY AND WATER USE

Building size and age are indicators of a building's benchmarked energy use. For example, in New York City, larger buildings, and particularly larger office buildings, report more energy use per square foot. The largest office buildings, those occupying over one million square feet, use 37 percent more energy per square foot than buildings occupying fewer than 100,000 square feet (Figure 36). However, there are other factors related to size that may increase energy use. One such reason is that larger office buildings tend to attract commercial tenants with higher energy demands, such as those found in the financial services or communications industries.[54]

Similarly, a building's age is another predictor of its energy use. This is true, in part, because building codes, available technologies, and the material preferences of architects and builders change over time, and each of these has a clear impact on energy use. Buildings built before 1910, for instance, tend to use the least energy per square foot, while postwar buildings are increasingly energy intensive (Figure 37). Larger office buildings are driving up the energy use in each successive decade. Figure 38 supports this by demonstrating that

Figure 36: Median Energy Use Intensity by Gross Floor Area for Consistently Benchmarked Properties (LL84 data)

Larger benchmarked office buildings use more energy per square foot. However, building size does not appear to have an impact on year-to-year performance. (NYU CUSP)



[54] Durst, A. Council on Tall Buildings and Urban Habitat (CTBUH). (2015). Efficient Energy Production for High-Demand Tenants of Tall Buildings. Retrieved from http://global.ctbuh.org/resources/papers/download/2436-efficient-energy-production-for-high-demand-tenants-of-tall-buildings.pdf

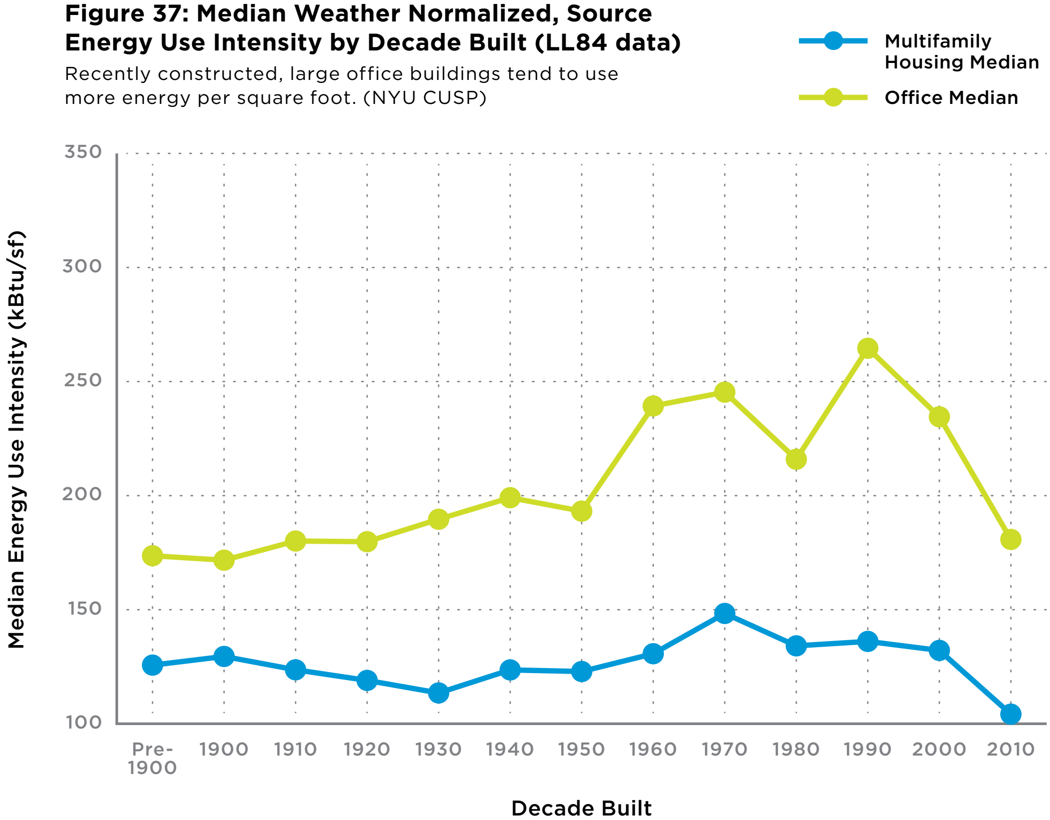
large buildings use more energy per square foot than mid-size buildings. More analysis needs to be done on large office buildings and additional metrics are needed to account for their increased size and energy usage.

The office sector also shows a more dramatic incline in energy use intensity in buildings built in the 1960s and 1970s. Given that these buildings use comparable lighting and equipment, such as computers, this dramatic change in EUI might result from the type of cooling system used, as central cooling became more common then; from changes in envelope construction; or, from other reasons. In addition, buildings constructed more recently might have characteristics such as higher worker densities or longer occupancy hours.[55] The decline in EUIs after the 1990s may reflect the impact of more stringent energy codes and greater enforcement efforts by the Department of Buildings (DOB). These possibilities may become substantiated as more data on equipment and building characteristics continues to be gathered under LL87. Since buildings built after the 1960s use approximately 25 percent more energy per square foot than those built before, this question deserves further study.

Another factor related to a building's age is its fuel mix (Figure 4). Properties built in the 1980s and before show greater use of heavy fuel oils—#4, #5, and #6 (Figures 38, 39). This is particularly true in multifamily properties, for which fuel represents up to 43 percent of energy use. (That compares with only 18

Figure 37: Median Weather Normalized, Source Energy Use Intensity by Decade Built (LL84 data)

Recently constructed, large office buildings tend to use more energy per square foot. (NYU CUSP)



[55] Durst, A. Council on Tall Buildings and Urban Habitat (CTBUH). (2015). Efficient Energy Production for High-Demand Tenants of Tall Buildings. Retrieved from http://global.ctbuh.org/resources/papers/download/2436-efficient-energy-production-for-high-demand-tenants-of-tall-buildings.pdf

Figure 38: Multifamily Energy Mix by Decade Built (LL84 data)

Large multifamily properties built before the 1980s rely on some of the heaviest fuels. (NYU CUSP)

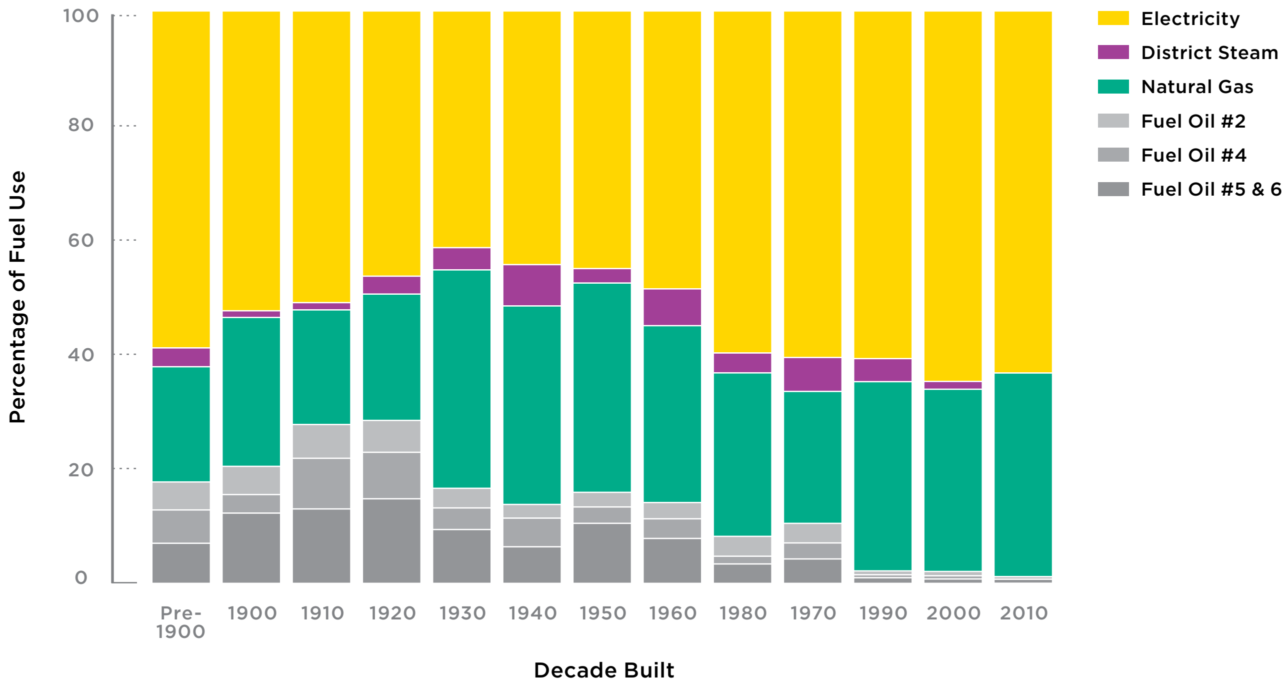
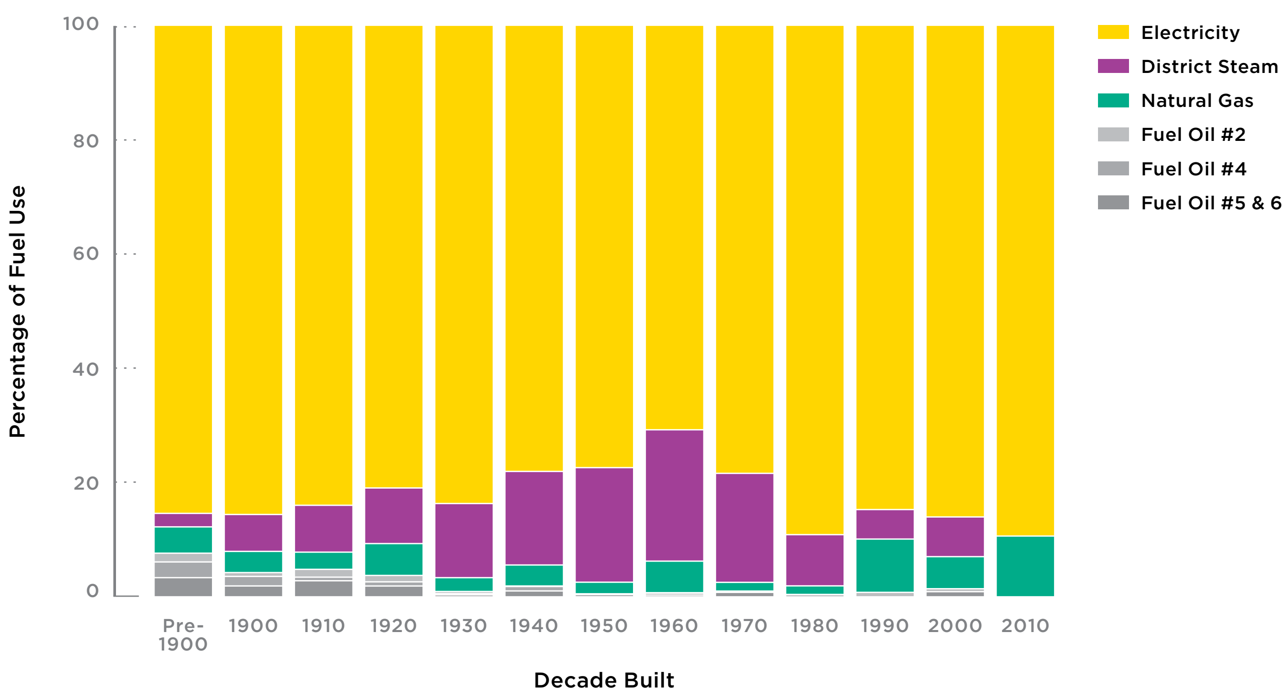


Figure 39: Office Energy Mix by Decade Built (LL84 data)

Benchmarked office properties rely on electricity and district steam as their main fuel sources. (NYU CUSP)



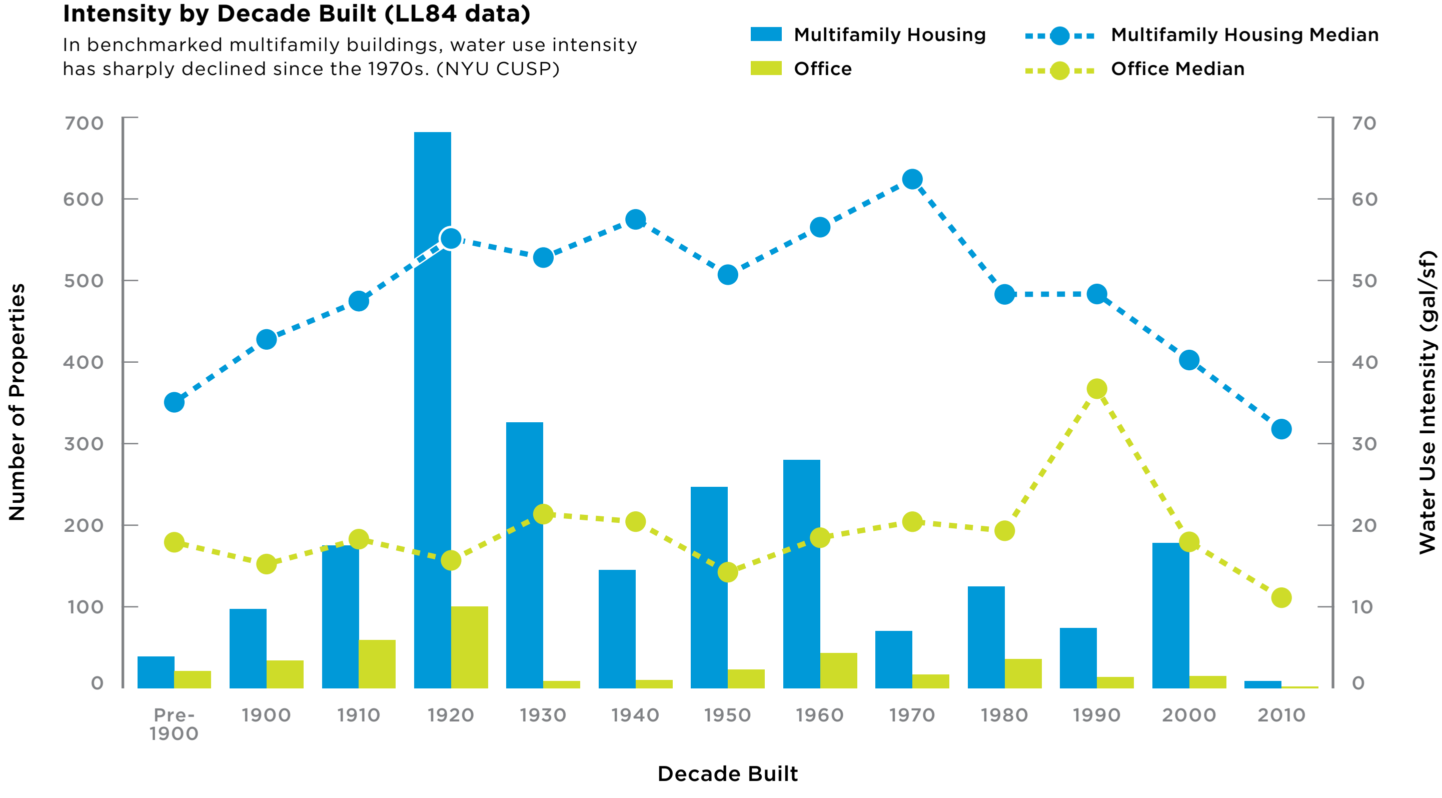
percent for office buildings.) This fact reinforces the findings from the LL87 data presented earlier in Figure 3, as higher oil and natural gas demand in the multifamily sector reflects the sector's substantial space heating needs. Meanwhile, electricity dominates office properties' fuel use, due to their higher demand for plug and process loads and cooling.

A building's date of construction is also an indicator of its water use. Here again, trends in multifamily and office properties differ. Compared to multifamily buildings built before 1900, the median water use intensity in those buildings is 56 percent higher in buildings built between the 1940s and the 1970s. Water use steadily drops in more recently constructed, benchmarked multifamily buildings, with buildings built in the 2010s using 53 percent less water than those buildings constructed in the 1970s (Figure 40). This may be due to increased stringency in federal standards, as well as increased awareness of water conservation.[56] In contrast, the WUI values of office buildings have been relatively stable over time, at around 20 gal/sf except for buildings built during the 1990s, for which water use intensity spikes to 36 gal/sf. One possible explanation for this increase is the use of once-through cooling systems that use potable water to cool condensers and then dispose of it. As further data is collected under LL87, this should be investigated.

The similarities between the chart shown here and that in the City's 2014 water data benchmarking report suggest that water data reporting is fairly consistent, bearing out DEP's efforts to improve water data accuracy. (See sidebar in Section 4).

Figure 40: Number of Properties and Water Use Intensity by Decade Built (LL84 data)

In benchmarked multifamily buildings, water use intensity has sharply declined since the 1970s. (NYU CUSP)



[56] Gleick, P. H. (2013). The World's Water: The biennial report on freshwater resources (Vol. 7). Chapter 7: U.S. Water Policy Reform. Retrieved from http://worldwater.org/wp-content/uploads/sites/22/2013/07/chapter_7_us_water_policy_reform.pdf

POLICY OPPORTUNITIES

Since 73 percent of New York City's carbon emissions come from energy used in buildings, benchmarking and audit data are crucial to helping the City craft impactful, data-driven programs and policies that will help achieve its goal of reducing citywide carbon emissions by 80 percent by 2050 (80 x 50).[57] Other cities will also look to New York City as a model for initiating studies at this level. Next steps toward reducing building energy use, improving the collection and quality of building energy data, and facilitating the use of that data include the following:

1. **Improve LL84 and LL87 Data Quality and Collection:**
    a. **Audit form working group:** The City intends to streamline and clarify the audit and retro-commissioning data collection forms. These forms allow building data to be logged digitally and then aggregated much more quickly than physical paper forms do. One example of the ways the forms can be improved is the adding of parameters to the digital audit forms that will rule out impossible technology combinations based on fuel types and end uses.
    b. **Accurate floor area:** Accurate floor area measurements are critical to assessing EUI and other measures of building energy and water use. Unfortunately, data collected under the local laws indicate that establishing and collecting accurate gross square footage is an ongoing challenge. In different datasets that include the same buildings, property floor areas differ by more than 10 percent and sometimes more than 30 percent (Figure 42 in Appendix). The City intends to explore methods of calculating accurate gross square footage measurements for each building, measurements that will be certified by a design professional.
    c. **Training for building owners and benchmarking consultants:** New York City intends to encourage the training of more benchmarking service providers. The City is monitoring benchmarking accuracy and will consider what training or certification programs or policies will best improve benchmarking services.
    d. **Building-level data:** Roughly 40 percent of New York City's total benchmarked area is comprised of buildings that share a lot with other buildings. Most of these buildings share meters and/or heating systems and so cannot be individually benchmarked. The City will work with NYSERDA and New York City utilities to increase sub-metering at the building level so that all large buildings can be benchmarked individually.
    e. **Automatic uploading:** The New York State Public Service Commission (PSC) should require utilities to provide automatic uploading of whole building energy data in order to make benchmarking easier, less expensive, and more accurate. The City is currently pursuing automatic uploads to Portfolio Manager from both Consolidated Edison and National Grid.

[57] The City of New York. (2016). Inventory of New York City Greenhouse Gas Emissions in 2014. Retrieved from www.nyc.gov/html/planyc/downloads/pdf/NYC_GHG_Inventory_2014.pdf

2. **Increase Impact and Usability of Data:**
   a. **Data cleaning and analysis coordination:** Data submission is never perfect, so datasets must be cleaned to remove incomplete, erroneous, and duplicate entries. Many organizations and individuals are interested in examining both LL84 and LL87 data. Since these groups tend to work independently, all have employed their own cleaning methods. The City intends to develop a standardized cleaning methodology that includes open source, modular cleaning scripts that can be curated and maintained by building science experts. The City will also coordinate with national efforts, such as Lawrence Berkeley National Laboratory's data cleaning protocols used in the U.S. Department of Energy (DOE)'s Standard Energy Efficiency Data Platform (SEED),[58] in order to create more systematic benchmarking metrics nationally.
   b. **Accessibility of Data:** The City will explore making more LL84 data fields available for public disclosure, including fuel type, while preserving privacy and data security.
   c. **Asset Score:** Benchmarking is an operational rating of how a building actually uses energy. An asset score can be a useful theoretical rating. It assesses the underlying physical characteristics and energy systems of a building independently of how the building is operated or occupied. DOE has a free, standardized tool for calculating a building energy asset score. The LL87 reporting requirements include almost all the information necessary to create an asset score using this tool; only geometric data appears to be lacking. New York City is currently working with the DOE to determine the feasibility of automatically creating an asset score for building owners who have complied with LL87. The asset score may be useful in helping better understand building energy use. New York City intends to expand the LL87 reporting requirements to facilitate the generation of an asset score.
3. **Expand Reporting Requirements:**
   a. In April 2016, the City introduced an amendment to expand the LL84 reporting requirements in order to encompass more buildings and held a hearing in June 2016. Lowering the reporting threshold from 50,000 square feet to 25,000 square feet will add roughly 10,000 properties to the set, increasing the amount of covered floor space to almost 60 percent of New York City's gross square footage, increasing data access for more New Yorkers.[59]

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[58] This is an open source software application created to validate, clean, and manipulate building performance data. For more information, please see DOE's website: http://energy.gov/eere/buildings/standard-energy-efficiency-data-platform.

[59] This percentage was calculated using the Department of City Planning (DCP)'s Primary Land Use Tax Lot Output (PLUTO) database.

IMPROVEMENTS TO DATE

New York City has made great strides over the past few years to improve data quality, accessibility, and building energy use, including:

DATA QUALITY

Department of Buildings Data Quality Enforcement

In March 2016, in an effort to improve data reporting, DOB issued a service notice informing building owners that benchmarking submissions will be reviewed for completeness and accuracy using a nine point review process. Building owners who submit data before the May deadline will have an opportunity to have their data reviewed by DOB and receive confirmation of whether their reports need to be corrected and re-submitted.

NYC Benchmarking Help Center

In December 2015, the City re-launched the NYC Benchmarking Help Center in partnership with the City University of New York Building Performance Lab (BPL) and the Building Energy Exchange (BEEx). Its aim was to increase LL84 compliance rates, improve benchmarking data quality, and support building owners new to LL84 and Portfolio Manager. The Help Center provides full-time live service by email, phone, and website, coordinates with agencies and utilities, and answers technical questions relating to reporting building energy and water data to the City. With DOB's data quality enforcement program underway, the Help Center is prepared to support building owners in meeting data accuracy requirements. More information is available at www.nyc.gov/ll84helpcenter.

ACCESSIBILITY

Two web-based tools have been developed to make it easier to access building level benchmarking data.

The New York City Energy & Water Performance Map

The New York City Energy & Water Performance Map, developed by NYU CUSP in collaboration with the NYC Mayor's Office of Sustainability, is a web-based visualization tool that shows how benchmarked buildings' energy and water use and GHG emissions compares to similar building types. Launched in December 2015, the map empowers New Yorkers to understand the energy, water, and climate change impacts of the spaces they rent and buy, and to identify top performing buildings in the city. It does this through an intuitive interface that provides energy and water efficiency details for specific buildings and ranks their energy and water use. It includes detailed analytics building performance and allows for queries of buildings by age, type, and size, and is accompanied by additional academic research.[60] The map is available at www.nyc.gov/benchmarking.

Metered New York

Metered New York, developed by Urban Green Council, uses publicly available information and data from LL84 to provide user friendly graphs and charts that help users understand building energy use information at a glance. The website's powerful search feature makes it easy to locate any benchmarked building. Meanwhile, a robust filter system makes it simple to see, for instance, which

[60] Kontokosta, Constantine E. and Christopher Tull. 2016. "EnergyViz: Web-Based Eco-Visualization of Urban Energy Use from Building Benchmarking Data," Computing in Civil and Building Engineering

Brooklyn office properties built before 1950 are the best—or worst—performers. More than just a repository of performance data, Metered is designed to educate users about the factors underlying property statistics—and more importantly, how to improve them through training and incentives. Metered also provides tips and resources alongside relevant property report cards, so that users can see which upgrades are available at the moment they are discovering these buildings need them. Metered is available at www.metered.nyc.

BUILDING PERFORMANCE

NYC Retrofit Accelerator

In September 2015, Mayor de Blasio launched the NYC Retrofit Accelerator, a program that provides free technical assistance and advisory services to building owners undertaking critical energy efficiency, water conservation, and clean energy upgrades. The program is anticipated to reduce citywide greenhouse gas emissions by roughly one million metric tons per year by 2025—the equivalent of taking almost 200,000 passenger vehicles off the roads—by accelerating retrofits in as many as 1,000 properties a year by 2025. These retrofits can save New Yorkers an estimated $350 million a year in utility costs, all while generating more than 400 local construction-related jobs. In addition to helping building owners reduce operating costs, raise asset values, and improve occupant comfort, the Retrofit Accelerator assists in LL87 compliance by clarifying the requirements, providing the updates, suggesting compliance timelines, and more. Additional information is available at www.nyc.gov/retrofitaccelerator.

Community Retrofit NYC

In April 2016, the City launched an outreach and assistance program called Community Retrofit NYC to help owners and operators of small and mid-size multifamily buildings in Central Brooklyn and Southern Queens implement energy and water efficiency upgrades. This program complements the NYC Retrofit Accelerator, which is geared towards larger buildings that must comply with the City's existing building energy laws. Community Retrofit NYC will develop a community-driven approach to engage buildings owners in pursuing energy and water saving improvements and will provide technical and financial guidance to assist building owners and decision-makers throughout the retrofit process. In addition, the program will help building owners connect with the NYC Department of Housing Preservation and Development's new Green Housing Preservation Program. That program provides low- and no-cost financing for water and energy improvements, and moderate rehabilitation in exchange for a commitment to affordability. More information is available at www.nyc.gov/communityretrofit.

APPENDIX

APPENDIX A
OVERVIEW OF METHODOLOGY

This section presents the basic terms and approaches used in this report to analyze energy use and characteristics in New York City's buildings, as reported under Local Law 84 and Local Law 87. The terms referenced in this report are as follows:

Site and Source Energy

The terms "site energy" refers to the total metered energy used by an individual building over the course of one year, with fuels and electricity converted to thousands of British thermal units using standard physical conversion factors. Site energy expresses the total heat released inside the building by all the energy-consuming processes within it. The term "source energy" refers to the same energy consumed by a building, but includes the energy needed to produce the energy that was metered as it entered the building. This includes, for instance, the energy required to push gas through a pipeline and, on a much larger scale, the thermal energy used to generate electricity.

The U.S. Environmental Protection Agency (EPA) issues a list of conversion factors, by fuel type, that can help building owners convert site energy to source energy. The agency also offers regional factors that can be used to calculate greenhouse gas emissions from site energy.[61] New York City has created its own set of factors for use in its Greenhouse Gas Inventory.[62] Because LL84 requires building owners to submit their energy data through the EPA's ENERGY STAR Portfolio Manager® (Portfolio Manager) website, this report's source energy and emissions calculations are based on the EPA's conversion factors and are not directly comparable to the New York City Greenhouse Gas Inventory values.[63]

Energy Use Intensity

Energy use intensity (EUI), measured in thousands of Btus per square foot, allows for the comparison of energy use in large and small buildings. This measurement is the result of dividing either the site or the source energy used in a building by its total floor area. (Note that this measurement uses the total floor area, not the heated or otherwise qualified floor area.) In general, this report focuses on source EUI since this is the environmentally important quantity and is more closely tied to emissions.

Space Heating Fuel Use Intensity

A more specific metric was necessary for analyses that focused on how heating and distribution systems affect space heating energy use. These analyses were

[61] U.S. Environmental Protection Agency. (2013). ENERGY STAR Portfolio Manager Technical Reference: Source Energy. Retrieved from https://portfoliomanager.energystar.gov/pdf/reference/Source%20Energy.pdf

[62] The City of New York. (2016). Inventory of New York City Greenhouse Gas Emissions in 2014. Retrieved from www.nyc.gov/html/planyc/downloads/pdf/NYC_GHG_Inventory_2014.pdf

[63] U.S. Environmental Protection Agency. ENERGY STAR Portfolio Manager. Retrieved from https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/use-portfolio-manager

performed on a merged LL87-LL84 dataset, discussed further in Appendix B. This was important in allowing the use of LL84 fuel data, which has a defined reporting period of one calendar year. By contrast, LL87 data might use modeling software to extrapolate space heating energy use and thus might not accurately capture energy use.

To calculate the fuel energy use, each fuel type reported in LL84 in kBtus was converted to source energy use, using EPA's national conversion factors. Each fuel source use was multiplied by the fraction of energy devoted to space heating for that fuel type, reported in LL87.[64] This energy use was then divided by heated floor area, or the sum of LL87-reported "heated only" and "heated and cooled" floor areas, to find the space heating fuel intensity.

Greenhouse Gas Emissions

Greenhouse gas emissions are reported in kilograms of carbon dioxide equivalent (kg CO_2e), a measure that includes other greenhouse gases such as methane, which are then reduced to a single reporting number. Again, because this calculation is made by Portfolio Manager, these results are not comparable to those calculated using the New York City Greenhouse Gas Inventory.

Building Sectors, Classes, and Characteristics

This report describes the energy use of various New York City buildings sectors. The classes often used in this report included multifamily buildings, office buildings, hotels, as well as several other types of buildings. Building sectors are sometimes broken down further into sub-classes based on building age, size, or other characteristics. The number of buildings in a given class will also vary with the data cleaning techniques used, discussed in detail in Appendix B.

In general, the classes cited in this report are consistent with those of previous reports. The inclusion of LL87 data demonstrates that there are sometimes vast differences within classes. For that reason, for some figures, further size distinctions are presented where useful. Such distinctions show the

[64] LL84 reports fuel oils #2, #4, and #5/#6 separately, while LL87 reports all fuel oils in a combined field. The individually reported LL84 fuel oil uses were summed together in order to apply the space heating fraction from LL87.

differences among low-rise, mid-rise, and very large properties. Data about these distinctions can lead to the development of more targeted approaches and to recommendations for building system improvements. Future reports will continue to explore the many individual factors that affect buildings' energy use.

Area by System Technology

In the LL87 audit tool, auditors can report up to five pieces of equipment for most system types, including heating, cooling, and domestic hot water. To calculate the area by system type for each technology, only the first equipment reported (e.g. Heating System Type 1, Cooling System Type 1, etc.) was counted. This captures submissions that reported only one system type and is in line with the analysis of other organizations reporting on LL87 data. Still, this may lead to overestimating the prevalence of systems reported first while underestimating those systems that are reported subsequently. The LL87 audit tool, however, only collects qualitative data on the areas served. Including quantitative estimates of the area served by equipment in the auditing tool would facilitate more accurate reporting.

There are a few exceptions to the above. The tool collects auditors' estimates of the percentage of area served by lighting systems and lighting controls. For those graphs (Figures 11 and 12), the area shown reflects these percentages, and all ten fields for lighting and five fields for lighting controls are considered.

The cooling system graph (Figure 13) also presents cooled floor area for the first cooling system reported. This was found by summing two LL87 fields: area cooled only and area cooled and heated. However, there is considerable uncertainty surrounding how auditors reported breakdowns of conditioned areas. Some appear to have reported cooled area only if it is centrally cooled, while others included area cooled by both central and local systems. As a result, these estimates likely underestimate the prevalence of tenant-based systems, such as window and through-wall A/Cs.

Medians

The descriptions and comparisons of the energy use and the characteristics of various classes of buildings have been carried out using standard statistical-analysis tools. Most of these descriptions and comparisons were generated using the programming language Python.[65]

The median, the point at which half of the rank ordered data points falls above or below, and the quartiles, the four equally distributed groups of data points, provide a clear picture of energy use within a single type of building. These tools help building owners and managers assess how their properties use energy relative to others in the same building sector. Medians work well in data sets that can be easily divided into smaller groups for detailed analysis. This is usually true in historical comparisons of different existing buildings with known locations, construction types, construction years and systems. Medians do not take building size into account, so each building is given equal weight. This means that medians cannot be used to find the total energy use of a sector, even if the sector's total area is known.

[65] Python. Retrieved from https://www.python.org/about/

APPENDIX B
DATA ACCURACY AND TREATMENT

The final LL84 and LL87 datasets used in this analysis are products of rigorous cleaning processes that removed outliers and entries that contained errors or failed to report necessary information. New York University's Center for Urban Science and Progress (NYU CUSP) and Urban Green Council (Urban Green) used similar strategies for cleaning the datasets, as outlined in the following sections.

LL84 Data Cleaning

NYU CUSP and Urban Green went through two rounds of cleaning the original 13,138 entries in the LL84 dataset. The first round removed entries that did not report or misreported identifying information, such as the borough, block, and lot (BBL) number. The organizations also removed duplicate entries, in addition to entries that contained the same identifier, such as the Portfolio Manager ID or BBL number, but differing property information. The second round of cleaning identified and removed entries with questionable energy or water data.

NYU CUSP

When dealing with duplicate entries, NYU CUSP kept only the most recently submitted entry. However, entries with duplicate BBLs were kept if each entry had a unique Building Identification Number (BIN) in order to allow for buildings on the same lot to report separately. Where feasible, missing values in the most recent record were imputed from earlier, duplicate submissions.

To define upper and lower limits for energy and water use outliers, NYU CUSP used a statistical method to remove weather normalized source energy use intensities and water use intensity values at the tails of the distribution. First, the data were log-transformed based on EUI, as its unaltered distribution is asymmetrical and has the right-skew characteristic of a logarithmic-normal distribution. Taking the natural logarithm of EUI normalizes the distribution and allows for the use of the standard deviation as a threshold to detect outliers. Following the logarithmic transformation, observations greater or less than two standard deviations from the calculated mean are flagged as outliers and dropped from the analysis dataset. This outlier detection methodology was applied by building type, so the distributional analysis is conducted for Office buildings, Multifamily buildings, and "Other" properties independently. Cleaning was conducted based on the unique distribution of the variable of interest.

The outcome of CUSP's cleaning process resulted in 8,688 entries with cleaned energy information and 3,183 entries with cleaned water information.

Urban Green Council

In addition to removing properties with invalid or blank identifying information, Urban Green developed a process to identify different types of duplicates, and, in certain cases, selected the best entry according to a set of criteria. If the best entry could not be determined, all duplicate entries were discarded.

Urban Green also removed properties whose reported floor area was not within 30 percent of the area recorded for that property in a New York City Department of City Planning database called PLUTO. (PLUTO contains extensive land use and geographic data.) This cleaning was conducted because an analysis comparing areas reported in LL84, LL87, and PLUTO revealed substantial variation. That is, only 65 percent of the LL87 data and 60 percent of the LL84 data reported floor areas within 10 percent of the PLUTO-listed area. The 30 percent criterion allowed Urban Green to keep 85 percent of the data while removing properties with reported floor areas that were considerably different.

Urban Green adopted a building science approach to set lower and upper cutoffs of source energy use intensity. These cutoffs—50 kBtu/sf for the lower limit and 1,000 kBtu/sf for the upper limit—represent energy intensities at which a building is too cold or too warm to be habitable. For the lower limit, a site EUI of 70 and a source EUI of 100 kBtu/sf will maintain an internal temperature around 60° F in typical New York City buildings. This report uses 50 kBtu/sf to be slightly more inclusive. This lower limit did not apply to non-refrigerated warehouses, garages, and other expected low-energy users. For the upper limit, a site EUI greater than 500 and a source EUI greater than 1000 kBtu/sf would require more than seven air changes per hour to remain below 85° F, and was considered unreasonable.

To establish which buildings to clean from the water use data set, Urban Green used a statistical approach similar to the one used by NYU CUSP. A natural log transformation was applied to the data to produce a more normal distribution. Then, for multifamily and office properties, outliers more than two standard deviations from the natural log mean were discarded in each sector. The remaining property types were cleaned using the global mean and standard deviation of the cleaned dataset.

While analyzing the LL84 data, different metrics were often the basis for comparison. For example, when comparing multiple years of data, weather normalized source EUI is the better metric to use, since it controls for annual variation in weather. When conducting analyses that focus only on 2013 data, this is not necessary, and source EUIs can be used. The benefit in the latter case is that it allows for a larger dataset, since more properties list source EUIs than weather normalized source EUIs, due, in part, to Portfolio Manager algorithms. To allow for situations such as this, Urban Green developed a flagging system to identify erroneous data and removed only the flagged entries relevant to the topic.

The outcome of Urban Green's cleaning process left 8,995 entries for source energy use analyses, 7,590 entries for weather normalized, source energy use analyses, and 3,515 entries for water analyses.

LL87 Data Cleaning

NYU CUSP and Urban Green Council analyzed two years of submitted LL87 audit data, from 2013 and 2014. The cleaning process for the LL87 data set was more involved than that for the LL84 data set. Because auditors input audit information into Microsoft Excel forms manually, standardizing the formatting and language of these entries required more effort. Additionally, the cleaning process relied more on flagging entries than on discarding them. Because there are many variables that can be analyzed independently of each other, flagging enables the inclusion of properties that report on one variable, such as energy conservation measures, while not reporting on another, such as heating system type.

NYU CUSP

Each record in the compiled LL87 audit dataset consisted of a row of entries, where features represented the fields from the Energy Audit Data Collection Tool. For proper analysis, data needed to be extracted, cleaned, and transformed. Because energy consultants entered numeric and categorical data manually, features were cleaned to identify and correct improper and missing entries. Non-numeric records that could not be directly converted to numbers were stripped of spaces, commas, and appropriate units (e.g. kBtu for Energy Savings). The remaining non-numeric records, which consisted of symbols, comments, and indications that the data was unavailable, were identified as missing data for the purpose of analysis. Categorical data was also cleaned and manipulated for input in models. For certain categorical inputs, specifically Heating System Type and Exterior Wall Type, there were significant differences between how individual auditors entered data. For example, in the Heating System Type field, where the Fuel Source was district steam, some auditors entered the Heating System Type as Steam Boiler while others listed it as Other.

For Exterior Wall Type, many auditors with Mass walls listed wall type as Other and described the wall as masonry, concrete, or brick in the comments field. For all exterior walls that had one of these words in the comments, the wall type was changed to Mass. Additionally, the year of construction of the building was recoded to categorical bins of Before 1901, 1901 – 1920, 1921 – 1946, 1947 – 1970, 1971 – 1990, and After 1990. The Build Period divide in 1947 represents the observed separation of “Pre-War” and “Post-War” buildings. The year of construction field was recoded to account for observed non-linearity in the effects of build year on energy use and efficiency (Kontokosta, 2015, 2012).

ECM recommendations were converted in a similar manner to systems data. For each property (identified by the Borough Block Lot number or “BBL”), the number of recommendations in each category and the sum of energy savings, cost savings, and implementation cost are calculated. Finally, for each BBL, the presence of an ECM recommendation in each category is determined for each building in the dataset.

After data was transformed as previously discussed, records were removed based on the following rules: (1) the BBL was duplicated in the LL87 dataset; and (2) the auditor recommended no ECMs. It should be noted that due to the guidelines for entering data in the Energy Audit Data Collection Tool, it is possible for multiple buildings on the same lot to report individual audits and records. In this case, duplicate BBLs could represent different buildings; however, this could not be determined with sufficient certainty for this study. Audits without ECM recommendations were considered incomplete thus were removed for this analysis.

Urban Green Council

Urban Green's data cleaning was also broken down into several stages. The first stage of general cleaning involved consolidating the information that the DOB had collected, ensuring the consistency of Building Identification Numbers throughout a single Energy Efficiency Report, and removing any duplicates found within the separate 2013 and 2014 LL87 datasets and the merged dataset. This produced a final cleaned dataset containing 2,328 entries.

The next stage of cleaning depended on the topic of analysis. In analyzing the prevalence of building systems, entries that could not be linked to PLUTO and those missing relevant system type information were flagged and discarded as inappropriate. For analyses that required merging with LL84 (described in greater detail below), cleaning steps included removing entries with missing reported floor areas and PLUTO areas, inadequate fuel information, calculated source EUIs not within the limits of 50 to 1,000 kBtu/sf, and floor areas not within 30 percent of reported PLUTO areas. After applying these latter steps, 2,060 entries remained.

Merged Data Cleaning

Urban Green's analyses often required a merged LL84-LL87 dataset, such as when investigating the impact of central distribution system type on water use. Accurately combining these datasets required managing several issues. Namely, properties found in both LL84 and LL87 datasets often reported considerably different floor areas and energy use intensities.

The chart above indicates the extent to which the floor areas differed between properties that reported data under both LL84 and LL87 (Figure 41). Only about 30 percent of properties reporting in both years estimated the same property floor area and are indicated by the points along the 45° line. However, the trend line's skew away from 45° indicates that areas reported in benchmarking are smaller than the LL87 auditors' estimates. The cause of this discrepancy could have significant policy implications and should be pursued in further studies. For the purposes of combining these datasets for this report, Urban Green discarded properties if their LL84- and LL87-reported areas were not within 10 percent of each other.

Properties found in both the LL84 and the LL87 datasets sometimes also reported fuel information that resulted in different source EUIs. Properties listed in LL87 report only site EUIs, not source EUIs. So in order to make this

Figure 41: LL84 Reported Floor Area Vs. LL87 Reported Floor Area

Properties reporting under both LL84 and LL87 tend to have different floor areas reported in each data set. (Urban Green Council)

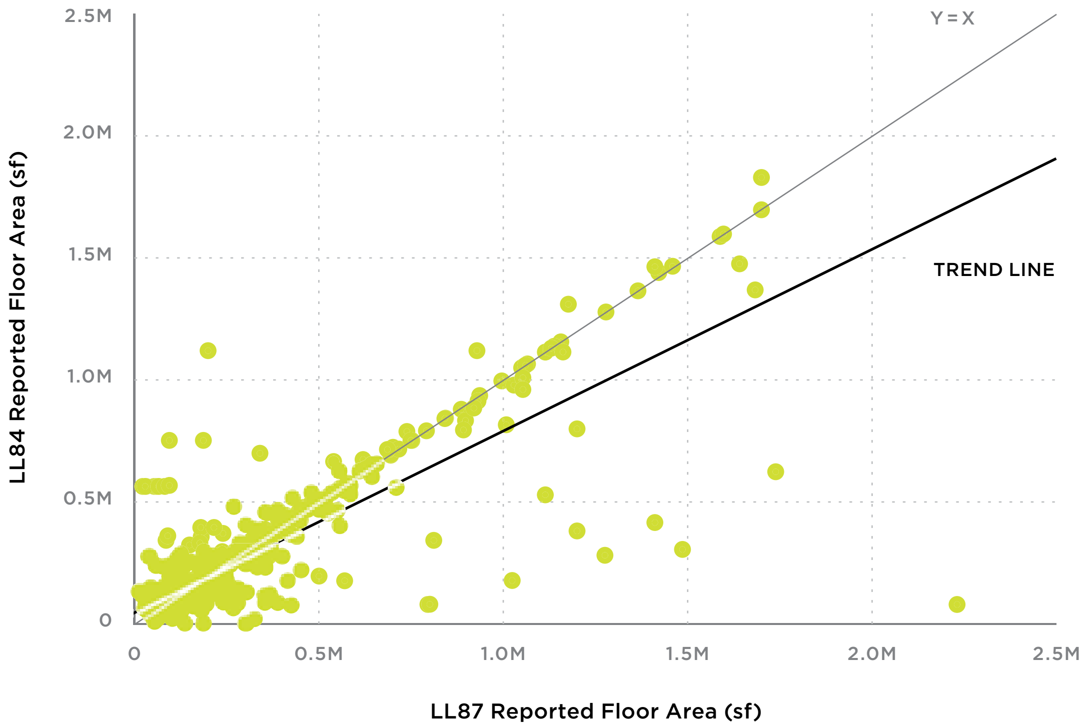
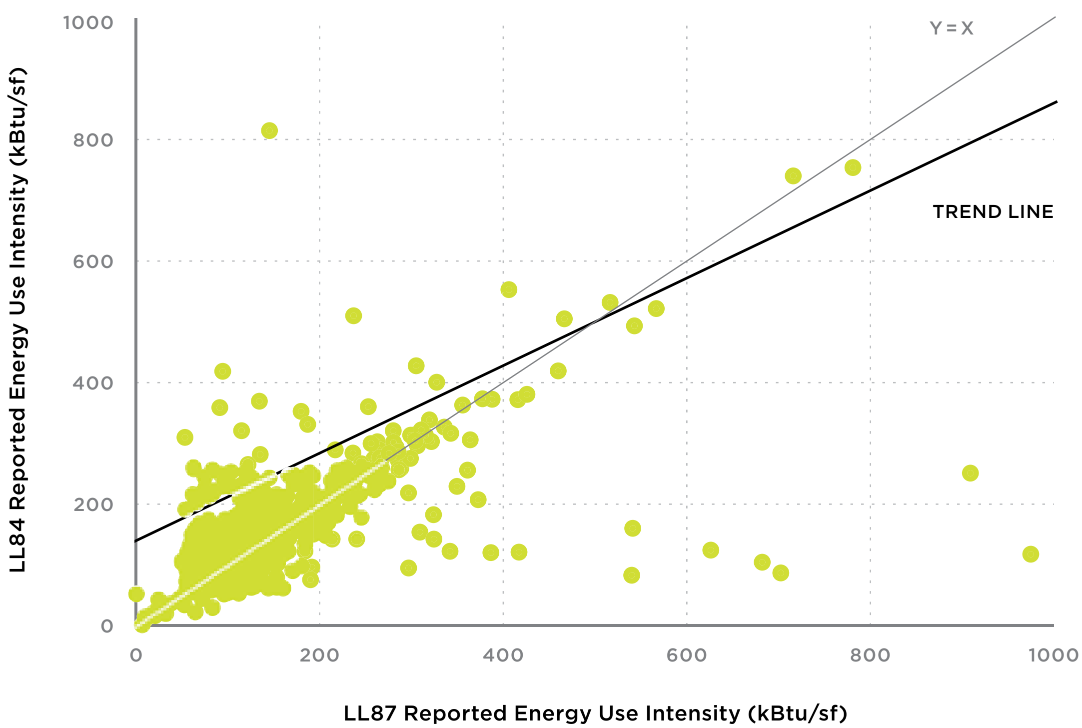


Figure 42: LL84 Reported Energy Use Intensity Vs. LL87 Reported Energy Use Intensity

Source EUIs for buildings listed in both the LL84 and the LL87 datasets often do not match. (Urban Green Council)



comparison, Urban Green used the fuel information provided in LL87 to calculate source energy use based on the same national coefficients used for the LL84 data. As the above chart shows, LL84 source EUIs tend to be lower than those reported in LL87 for the same property (Figure 42). Differences here may be a result of differently defined reporting periods. LL84 reporting is for a single, complete calendar year, whereas LL87 does not specify a reporting period. Due to the inability to accurately compare the EUIs, Urban Green did not discard any entries on the basis of EUIs. Instead, analyses using the merged dataset rely solely on LL84 energy data.

Combining the two datasets resulted in a total of 1,123 entries, about half the number of entries found in the cleaned LL87 2013-2014 dataset.

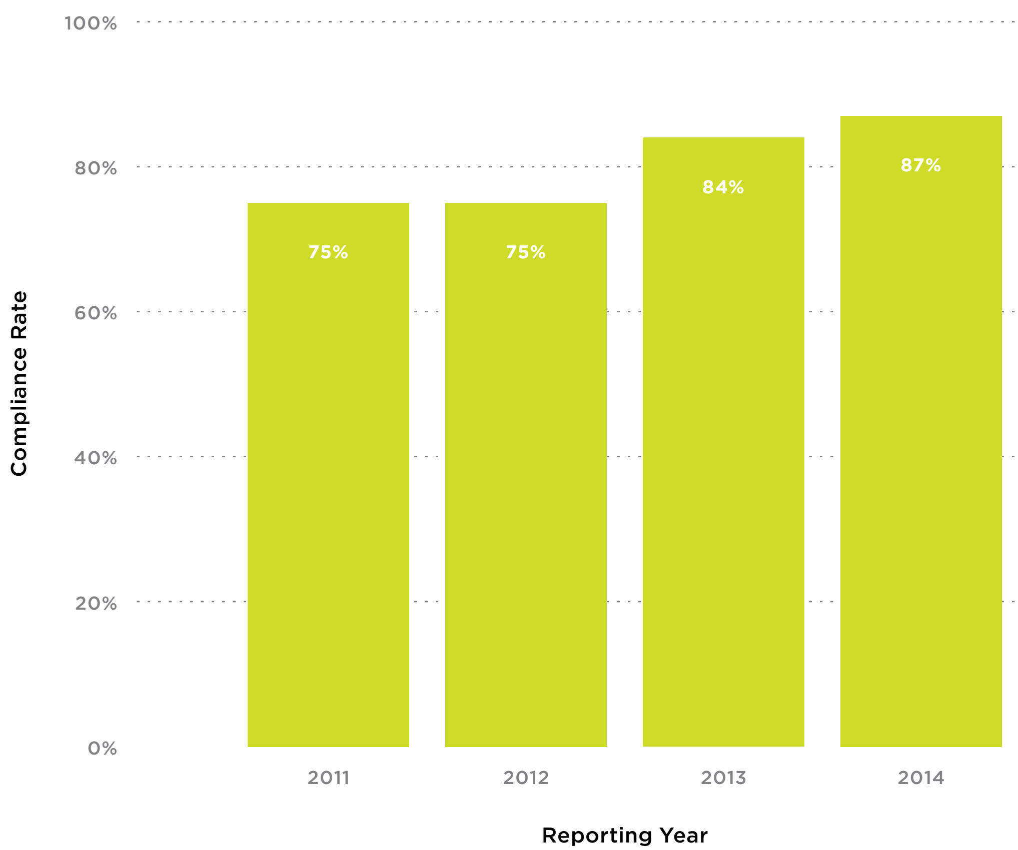
APPENDIX C
LL84 COMPLIANCE AND DATA QUALITY

Compliance with LL84 continued to improve with 2013 data reported in 2014 (Figure 43), with 87 percent of required properties submitting data. One possible source of improvement was building owners and data consultants becoming more familiar with benchmarking requirements.

One change for the 2013 data was the coordination between the Mayor's Office of Sustainability and the Department of Buildings to verify the accuracy of the

Figure 43: LL84 Compliance Rates

More of the buildings required to benchmark are complying with benchmarking rules. (Urban Green Council)

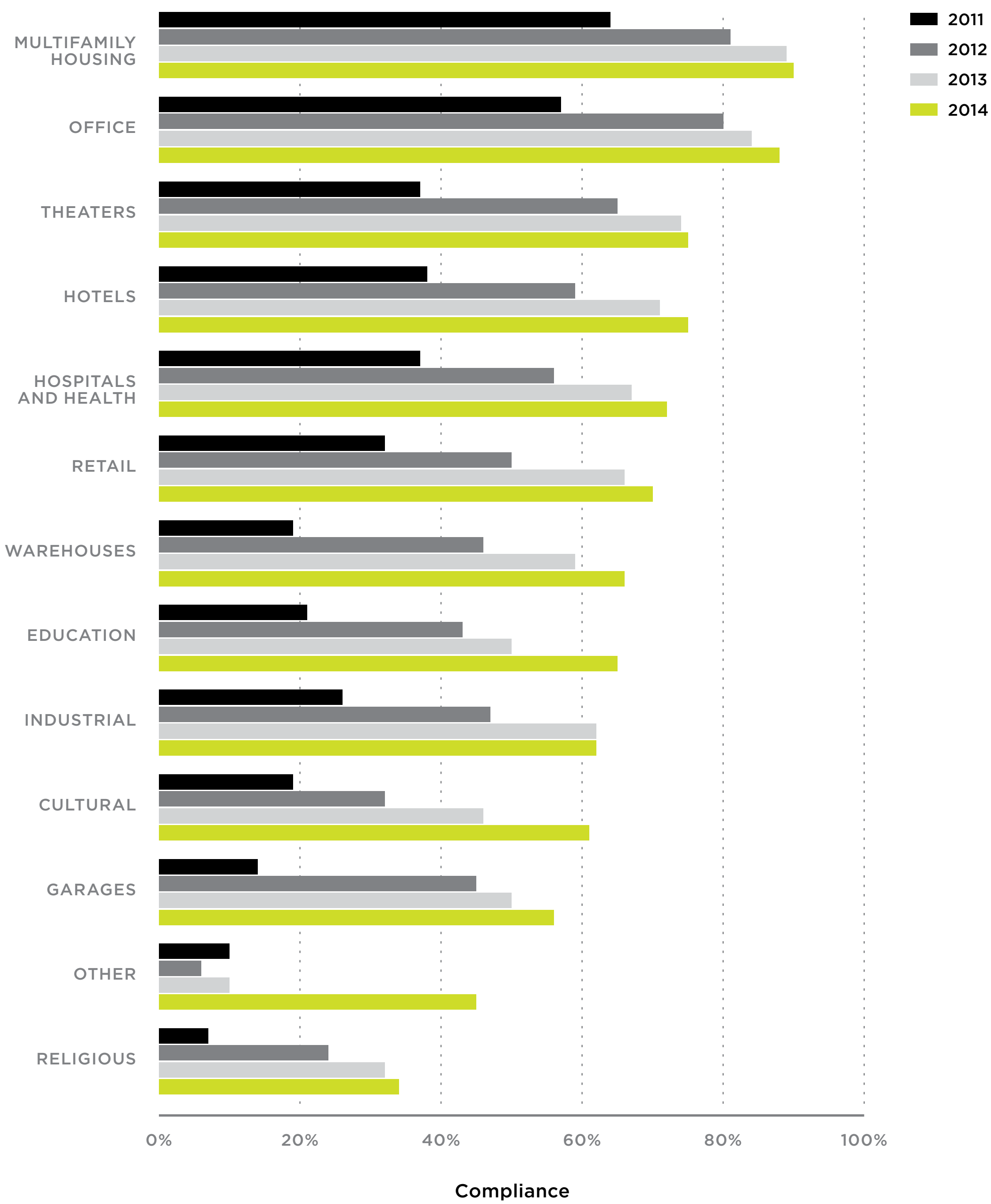


Covered Buildings List (CBL). This effort resulted in a new, more accurate list that will be used moving forward. Figure 43 reflects the compliance rate based on the revised Covered Buildings List for 2014 only.

Every property type has improved compliance over time (Figure 44). The multifamily and office sectors have had the highest and most consistent

Figure44: LL84 Compliance by Property Type Over Time

Multifamily and office buildings are taking the lead in compliance.
(Urban Green Council)

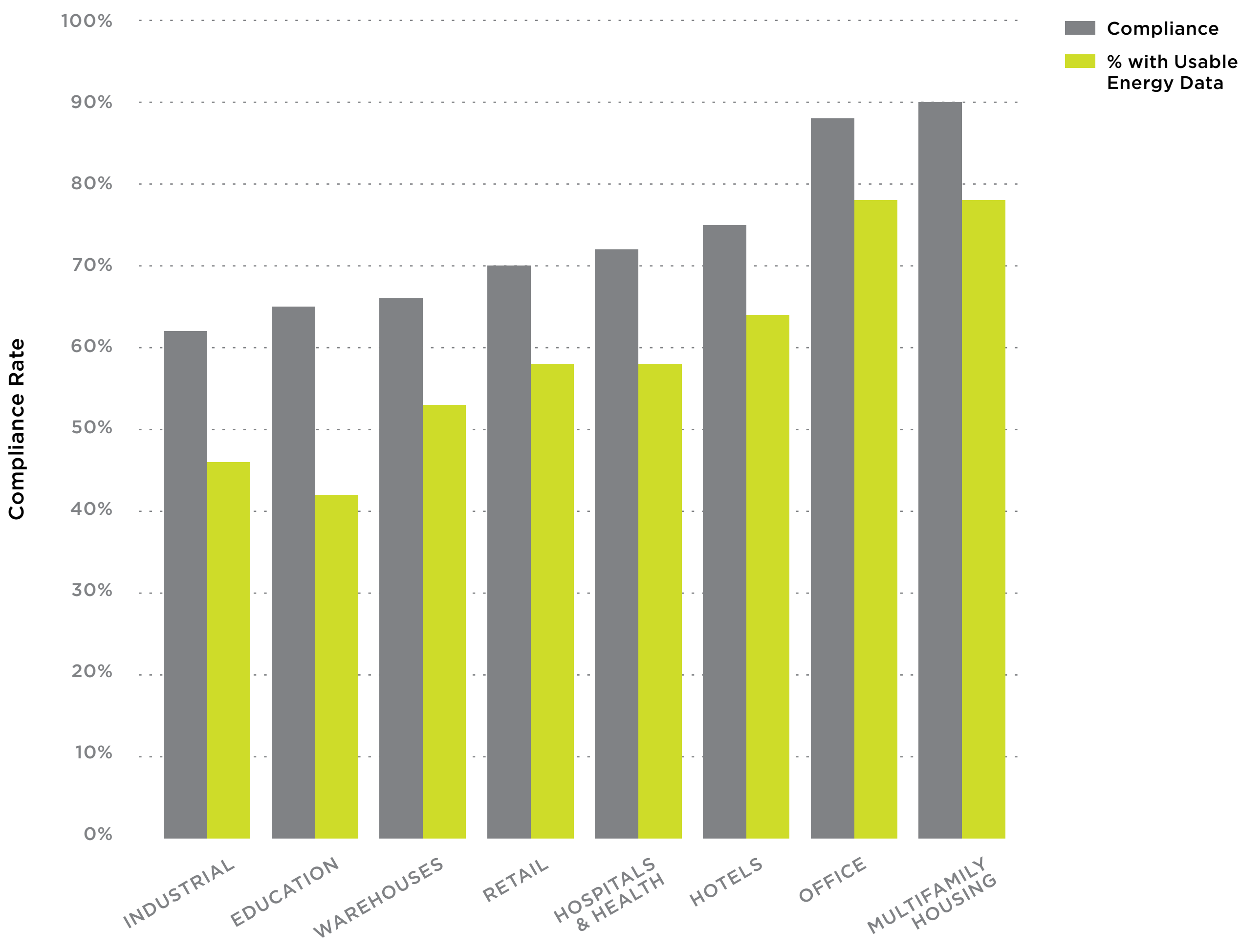


compliance rates, while warehouses and the education sector have seen the largest discrete percentage improvement during the four years of reporting.

Recently, DOB announced a standard for the data quality of submissions regarding missing or incorrect values in key fields.[66] In light of this announcement, this report examined the overall data quality of each sector for the 2013 benchmarking data, based on whether a submission provided valid energy data as defined in Appendix B. For each sector, the percentage of properties in compliance exceeded the percentage remaining after data cleaning. For example, while 90 percent of multifamily properties submitted data, only 78 percent submitted valid energy data (Figure 45). DOB's new requirements for compliance will likely call attention to the issue of data quality, and the expectation is this number will improve beginning with data submitted in 2016.

Figure 45: LL84 Compliance Compared to Validity of Energy Data

Analysis of data quality shows that the majority of compliant properties provide valid data. (Urban Green Council)



[66] For more information about DOB's latest changes to data compliance see their notice here: www1.nyc.gov/assets/buildings/pdf/ll84_change.pdf.

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