report

Evaluating New York City's Multifamily Building Energy Data for Savings Opportunities

Retrofitting Affordability

be
ex

building energy exchange

Report Partners:

BRIGHT POWER

sustainable energy partnerships

November 2015

This report is made possible by the generous support of:

Energy Efficiency for All

National Grid

Disclaimer

While every effort has been made to contain correct information, neither Building Energy Exchange nor the authors or project advisors makes any warranty, express or implied, or assumes any legal responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. None of the parties involved in the funding or the creation of this study assume any liability or responsibility to the user or any third party for the accuracy, completeness, or use or reliance on any information contained in the report, or for any injuries, losses or damages, arising from such use or reliance.

Reference herein to any specific commercial product, process, or service by its trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by Building Energy Exchange. The views and opinions of authors expressed herein do not necessarily state or reflect those of the Building Energy Exchange Board or Advisory Groups. As a condition of use, the user pledges not to sue and agrees to waive and release Building Energy Exchange, its members, its funders, and its contractors from any and all claims, demands, and causes of action for any injuries, losses or damages that the user may now or hereafter have a right to assert against such parties as a result of the use of, or reliance on, the report.

This November 2015 edition of the report has been updated to reflect additional data that became available after the June 2015 printing. This increased dataset more fully incorporates affordable properties, in particular NYCHA, into the analysis. With a more robust dataset, the findings better reflect the opportunity for energy savings and carbon reduction in New York City.

report

Evaluating New York City's Multifamily Building Energy Data for Savings Opportunities

Retrofitting Affordability

Photo: David McSpadden

contents

New York City's multifamily buildings are a diverse collection of properties that will play a pivotal role in meeting our climate change and affordability challenges.

This report analyzes newly available data in the New York City multifamily building sector to identify which buildings, and which energy efficiency retrofit measures, have the greatest potential for carbon reduction, and how these benefits relate to affordability and the City's climate action plan. Due to a very low vacancy rate and a high cost of maintenance, building owners are primarily focused on the day to day concerns of operating their buildings, and energy efficiency has not been a high priority. As a result, these buildings represent a significant opportunity to save energy, cut costs, reduce carbon emissions, improve comfort, and make a meaningful contribution to a healthier, more resilient, and equitable community.

Since 2010, New York City has required large buildings to report their annual energy and water use in compliance with the 2009 Benchmarking & Disclosure law. This law covers 2.3 billion square feet, nearly half the total square footage of all city buildings. Multifamily buildings represent 1.5 billion square feet, or about half of these covered buildings, and are responsible for 56% of greenhouse gas (GHG) emissions and 51% of source energy use. In 2013, energy auditors visited roughly 10% of these buildings, evaluating actual field conditions and providing energy saving recommendations in the first year of compliance with the 2009 Energy Audit & Retro-Commissioning law. Our analysis indicates this sample set of audited buildings is statistically representative of the entire 1.5 billion square feet of New York City's covered multifamily buildings, providing critical information on the highest impact, lowest cost retrofit opportunities as well as insights into the audits themselves and the data collection process.

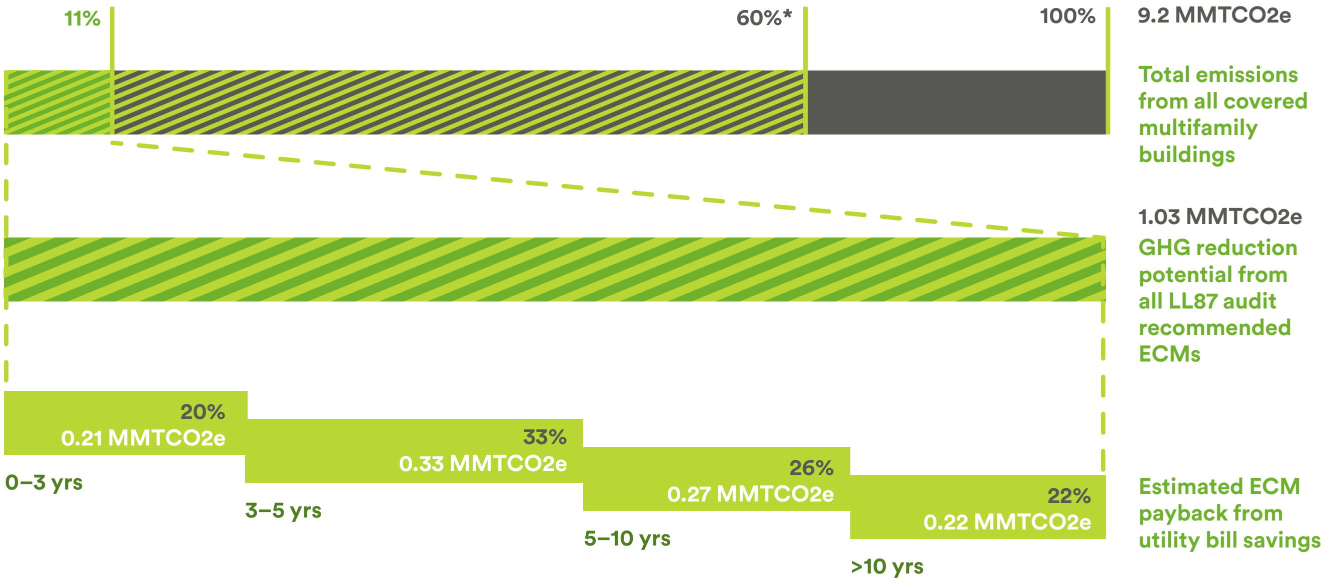
Our study organizes this diverse collection of covered multifamily buildings into twelve segments having similar characteristics and energy efficiency solutions. We study which multifamily sector segments have the greatest energy saving potential; which retrofit measures have the biggest impact and fastest payback; where the buildings with the highest potential for energy savings are concentrated; and how these opportunities relate to affordability.

Our analysis finds over 20 TBTU of source energy savings potential, an 11% reduction in total multifamily building energy use, and 1.03 MMtCO2e, an 11% reduction in GHG emissions. These figures are more significant when one considers that auditors typically focus only on systems controlled by the owner, which in many multifamily buildings represent only 50%–75% of the total building energy use.

Most important, this potential savings would be a first step toward the de Blasio administration's goal of reducing the City's carbon emissions 80% by 2050. It is broadly estimated that achieving this goal will require the building sector to reduce carbon emissions 60% by 2050. If this contribution is distributed evenly across all building types, the energy conservation measures studied here represent approximately 23% of the multifamily building carbon reductions required to meet this aggressive goal.

The auditor recommendations range from simple and inexpensive measures (installing LED lighting and insulating pipes) to more complex upgrades requiring significant capital expense (replacing windows or a boiler). However, 72% of the recommended energy conservation measures have a simple payback of less than ten years, while more than half pay back in less than five years, and 22% pay back in less than three years. Taken as a whole, the recommended retrofits are estimated to cost $2.1 billion, but would generate annual savings in excess of $360 million and

Figure 1: Scale of GHG Reductions This report identifies an 11% reduction in greenhouse gas (GHG) emissions from covered multifamily buildings, if all energy conservation measures (ECMs) are implemented. This chart shows how these savings compare to the City's 80 by 50 goals, and the expected payback.



* The City estimates that existing buildings will need to reduce GHG emissions by 60% in order to achieve 80 by 50 goals.

have a median payback in less than five years.

The analysis clearly identifies areas of potential focus. Three of the twelve building sector segments, all built after 1946, include more than half of the total identified GHG reductions, and just two categories of the energy conservation measures cited by the auditors represent 50% of the total energy savings potential.

Mapping this information onto the collage of New York City's diverse communities highlights neighborhoods with a greater concentration of affordable housing that also have a greater concentration of buildings with high potential energy savings, such as the South Bronx and central Brooklyn. These insights provide guidelines for a strategic approach to focusing benefits in the communities with the greatest needs.

Achieving these savings, however, will not be a simple matter. Energy efficiency is not a high priority for most property owners, managers, and operators, and those who do focus on energy efficiency often find that the true performance of retrofits has not been sufficiently documented to provide certainty of outcomes. Lack of access to capital is often a serious obstacle as well.

The City's new "Retrofit Accelerator" program will help

Key Findings

- Covered multifamily building audits identified a reduction of approximately 11% (20.9 TBTU) in total energy use, and an 11% (1.03 MMT-CO2e) reduction in GHG emissions, generating an annual savings of over $360 million

- Post-War buildings have more than half of the total identified GHG reductions, while representing 43% of the covered MF area, and 40% of the total estimated retrofit costs

- Just two categories of energy conservation measures, Domestic Hot Water and Heating & Distribution, provide 50% of the energy savings potential

- Over 70% of the recommended energy conservation measures have a less than ten year payback through savings on utility bills. More than 50% have a less than five year payback, and over 20% will pay back in under three years

- Several communities, including the South Bronx and central Brooklyn, have a high concentration of affordable housing with buildings that have excellent potential for energy savings

- Future energy audits need to be more aggressive in order to reach our climate action goals. Measured projects demonstrate that a 15%–25% energy savings is possible through comprehensive retrofits

building owners and operators navigate these barriers to unlock energy savings potential. Account managers will provide coordinated assistance to buildings with high potential for energy savings to connect them with training, financial assistance and other resources, increase the number of retrofit projects, and smooth the way for projects already underway. This analysis is intended as an early road map for the Accelerator to identify which types of properties might be targeted in which communities to produce the greatest carbon emissions reductions while preserving housing affordability.

The energy needs and usage of the building sector are enormously complicated and have only recently undergone the sort of broad data collection currently under analysis. Consequently, drawing strict conclusions from such data requires a degree of caution. With this in mind, the report frames some of the current limitations of the available data, and recommends improvements in the annual collection of what promises to be a tremendously important and insightful portrait of New York's vast building stock.

This report lights the path to a more efficient and resilient built environment through careful segmentation of the multifamily market and identification of the most commonly recommended energy retrofit measures, connecting these measures to affordability and ultimately to New York City's climate action goals.

introduction

Retrofitting Affordability comes at a turning point for New York City multifamily housing. Using both new and existing resources, this report looks to identify the greatest energy savings opportunities across a complicated sector to inform policy and provide guidance for more granular work moving forward.

New York City has the highest building density in North America, and multifamily housing comprises the majority of this area. Multifamily buildings are responsible for more energy use and greenhouse gas emissions than all other buildings combined, but until recently public knowledge about this energy use was limited and not widely dispersed.

Recent legislation mandating that large buildings report energy use and perform energy audits presents a unique opportunity to identify which building typologies and energy efficiency retrofit measures might most effectively reduce energy costs and green house gas emissions in this important sector. Widespread adoption of the measures identified in this analysis will significantly reduce carbon emissions while improving the affordability and quality of housing in New York City.

New York City Buildings

Almost every aspect of life in New York City, one of the oldest continually developed cities in North America, is dominated by its buildings.

The New York City real estate sector is among the most important in the regional economy. The cost, location and available services of the buildings in NYC largely determine where companies locate offices and where individuals choose to live, and the physical attributes of the city's buildings strongly influence the overall environmental impact of the city. There are 5.4 billion square feet of buildings in NYC, accounting for almost 70% of the city's total energy use and nearly 75% of the city's greenhouse gas (GHG) emissions.[1] These buildings provide living, working, and leisure space for more than 8 million residents, roughly twice the population of the second largest city in the U.S., Los Angeles. As a global hub of finance, technological innovation and social change, NYC is primed to establish a global leadership position in the transformation of the built environment.

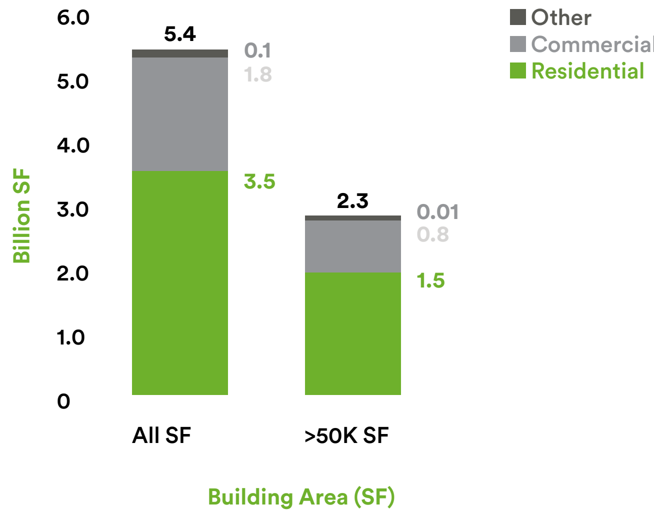
New York City buildings include structures as diverse as iconic skyscrapers, sprawling manufacturing hubs, and detached, single family homes, but the city is typified by large buildings. Buildings of over 50,000 square feet represent half of the entire built area of NYC (see Figure 2). The city's buildings are typically represented as three different sectors: commercial, residential, and "other" – which includes public, institutional, and industrial buildings. Of all the sectors that emit greenhouse gases in NYC, the residential sector has the greatest carbon footprint (34% of all emissions[2]), representing the biggest opportunity for energy savings and GHG reduction.

The groundwork for this evaluation of the energy savings opportunities in NYC buildings is based on a suite of laws that apply to all buildings over 50,000 square feet, or multiple buildings on a single property totaling over 100,000 square feet, referred to as "covered buildings". These laws, enacted in 2009 and collectively referred to as the Greener, Greater Buildings Plan (GGBP), include:

- **Energy Benchmarking and Disclosure Law (Local Law 84)**: Reporting and public disclosure of annual energy and water usage, beginning in 2010
- **Energy Audits & Retrocommissioning (Local Law 87)**: Conducting an energy audit and retro-commissioning every ten years, beginning in 2013
- **Lighting & Submetering (Local Law 88)**: Upgrading commercial lighting to meet current code, and sub-metering of large commercial tenants, by 2025

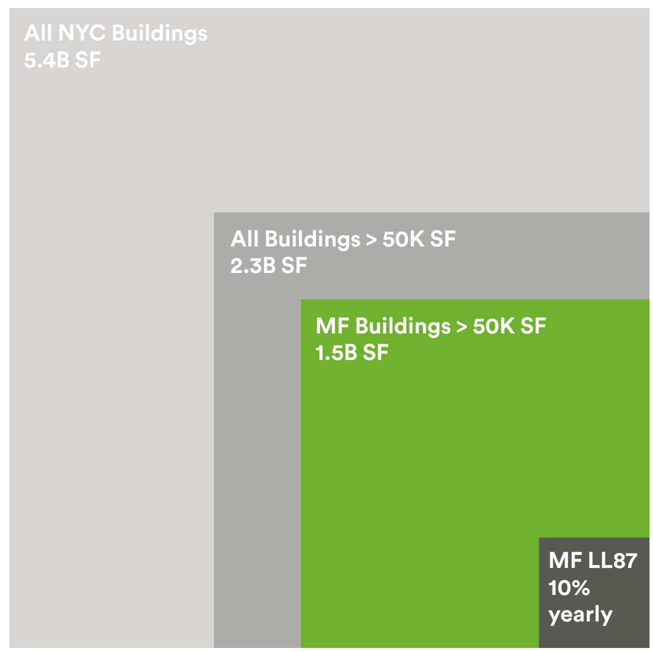
The information collected through the Benchmarking and Disclosure Law (Local Law 84) and Energy Audit and Retrocommissioning Law (Local Law 87) is submitted to the NYC Department of Buildings and forms the backbone of data used in this study to characterize and identify energy retrofit potential within the multifamily sector.

Figure 2: Area of NYC Building Stock by Use



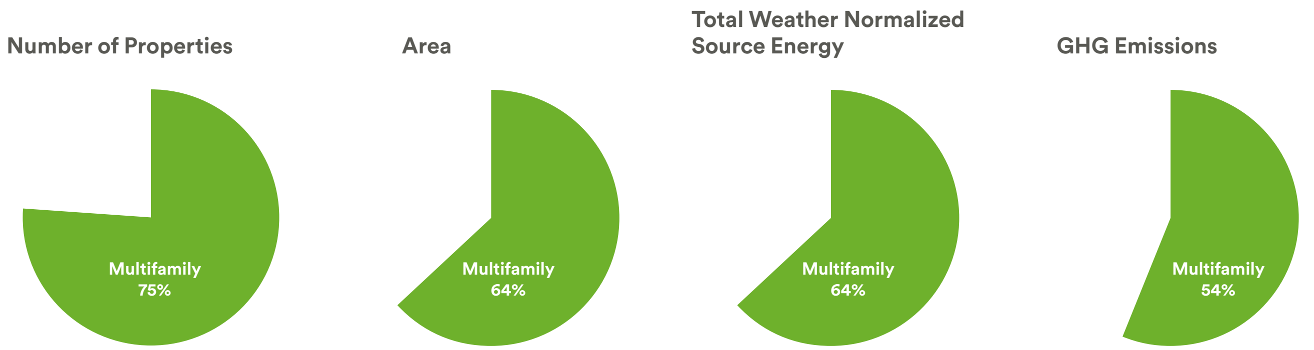
Residential buildings comprise the majority of New York City building area. This figure uses 2014 data from PLUTO and the City's Covered Buildings List.

Figure 3: Scale of Built Area



This report focuses on the energy savings opportunity from multifamily buildings over 50,000 SF using data from LL84 and LL87.

Figure 4: Characteristics of All Covered Properties[6]



New York City multifamily properties represent the majority of covered buildings properties and area, use the greatest amount of energy, and emit the most carbon dioxide. (Source: Mayor's Office of Sustainability, Year 3 Benchmarking Report, 2013)

New York City Building Language

"Covered" or "large" buildings refer to those buildings that are covered by the Greener, Greater Buildings Plan. This includes buildings over 50,000 square feet in area, or multiple buildings on a single lot totaling over 100,000 square feet in area.

Source Energy

Source energy is the total amount of energy needed to create all the energy consumed on the site. This includes all transmission, delivery, and production losses. Since source energy incorporates all of these aspects, it is a more equitable way to understand a buildings true energy usage. This report uses source energy to look at energy use and potential savings.

NYC's Multifamily Buildings

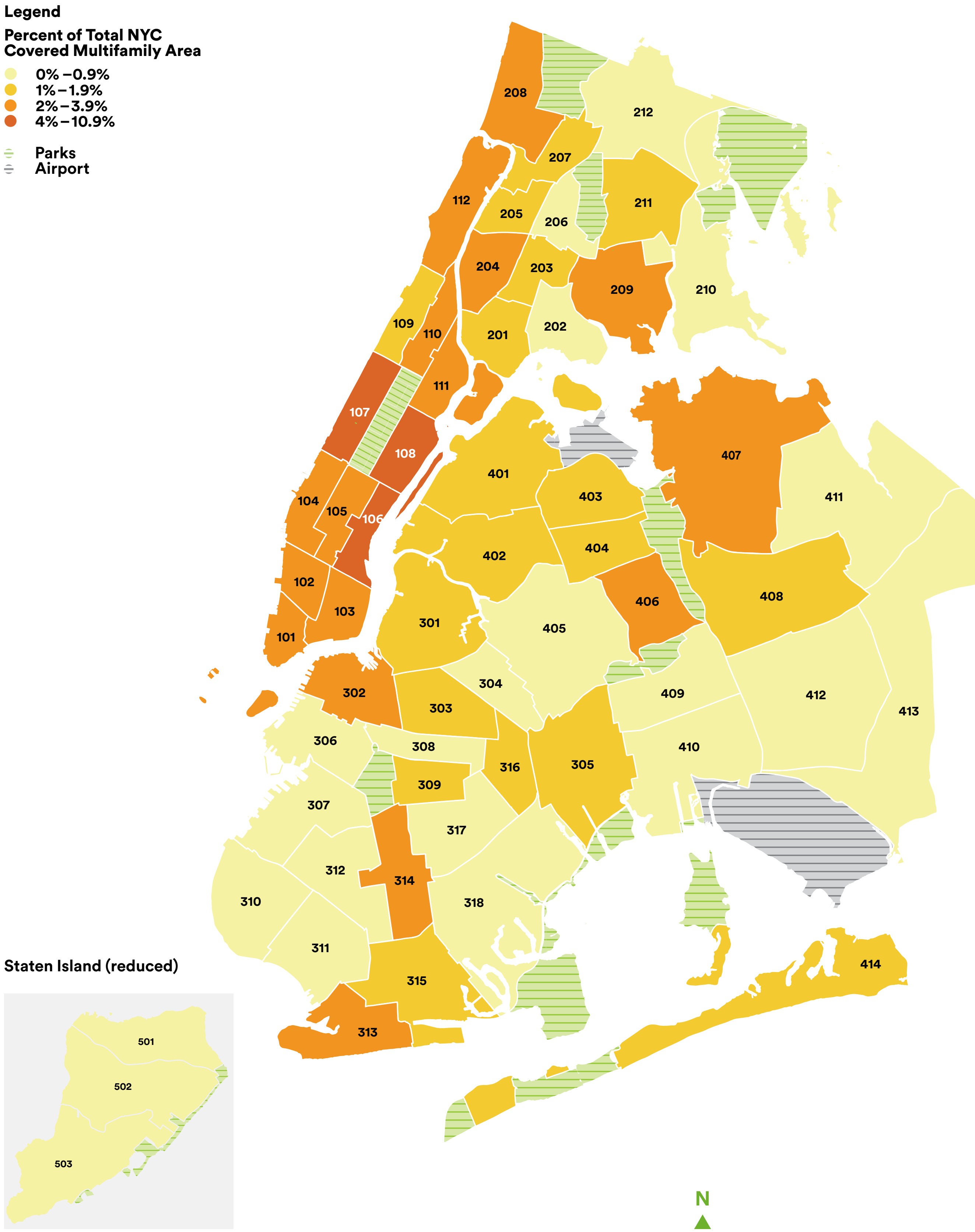
Of all New York City buildings, the multifamily sector provides the greatest potential for energy savings and carbon emissions reduction. Residential properties represent nearly 65% of all city buildings by area,[3] and over 50% of the greenhouse gas emissions from buildings overall.[4] In the city's covered buildings, the multifamily sector represents 75% of the properties, and over 50% of both the GHG emissions and the total energy use.[5] It is clear that large multifamily buildings must play a significant role in meeting the City's ambitious climate goals.

The potential for large multifamily buildings (see Figure 4) can be utilized throughout the city. According to an analysis of the Benchmarking Law data in 2012 by the Mayor's Office of Sustainability (MOS): "If all comparatively inefficient covered buildings (commercial, residential, and other) were brought up to the median energy use intensity (EUI) in their category, New York City consumers could reduce energy consumption in all covered buildings by roughly 18% and GHG emissions by 20%.[7]"

Multifamily housing is not only important to New York City's climate-related goals, it also forms the basis of our communities and neighborhoods. In recent years the cost of living in New York City has risen significantly, with the costs of operating our buildings one of many factors determining the quality of life here for many residents. Since 2002, rent and utility costs, refered to as "gross rent," in NYC have increased, while salaries have remained stagnant. Consequently, as of 2014, 56% of New Yorkers experience gross rent burden, paying more than 30% of their income in rent and utilities, and at least 30% are severely gross rent burdened, paying more than 50% of their income in rent and utilities.[8] This represents a 12% increase since 2000.[9]

Rising utility costs are a significant contributor to this problem. Though in most NYC multifamily properties building owners pay the fuel bills directly, owners can recoup these costs through rent increases.[10] NYC tenants have seen their utility costs increase by 20% over this time, while fuel oil costs more than doubled in the same period.[11] Rising energy costs have a disproportionate impact on lower-income New Yorkers who pay a higher proportion of utility costs relative to their income. Energy efficiency retrofits in these properties will lower utility bills

Map 1: Distribution of Covered Multifamily Buildings in New York City



Map 1 shows the distribution of the area of all covered multifamily properties. Darker areas show a higher density of multifamily square footage. Numbers identify NYC community districts. See the appendix for the index of neighborhoods.

BEEx: The Retrofit Accelerator Information Hub

In partnership with the New York City Mayor's Office of Sustainability and the NYC Energy Efficiency Corporation, the Building Energy Exchange (BEEx) will function as an information hub to connect Retrofit Accelerator stakeholders with actionable information that reduces friction for energy efficiency projects. The BEEx resource center in downtown Manhattan will act as a neutral location where prospective customers can be educated through events, training, technology demonstration, and exhibits, improving their ability to navigate the technical and financial challenges of undertaking retrofits.

and provide many quality of life benefits to these communities.

Large multifamily properties are found throughout the five boroughs, but just under half (47%) of covered multifamily properties are located in Manhattan (see Map 1). The map shows the distribution of the square footage of covered multifamily buildings throughout the city by community district (CD), a criteria chosen because it shows the neighborhoods without being too granular.

In Manhattan, the Upper East Side (CD 108), the Upper West Side (CD 107), and Midtown East (CD 106) have the highest concentration of these buildings, representing 25% of the city's large multifamily housing stock. Large multifamily properties are evenly distributed between the Bronx (16%), Brooklyn (20%) and Queens (16%). 1% of NYC's large multifamily properties are found on Staten Island. In the outer boroughs, the development of large multifamily buildings closely follows the subway lines – the B and Q lines in Brooklyn and the E, F, and 7 lines in Queens. The distribution of source energy use tracks very closely to the distribution of square footage of the multifamily buildings.

Knowing where the largest properties and energy users are located in the city can help inform decisions about priority areas for retrofits. This information, in combination with the *Retrofitting Affordability* analysis, which estimates the savings potential of large multifamily buildings throughout the city, will enable policy makers and industry stakeholders to improve upon existing climate mitigation policies and successfully implement new policies.

Mayoral Initiatives: The Retrofit Accelerator

Energy efficiency retrofits in multifamily housing improve both the affordability and the resiliency of NYC communities. Several current mayoral initiatives seek to bring energy efficiency retrofits to scale and realize a broad spectrum of sustainability and resiliency benefits.

The de Blasio administration is focusing on improving the energy efficiency of New York City's buildings, particularly multifamily buildings, as a key component of the City's 2014 climate action plan, *One City: Built to Last*. This ten-year plan sets an aggressive goal of reducing total New York City carbon emissions 80% by 2050, relative to a 2005 baseline. Buildings are likely to be the primary component of any plan to reduce the city's carbon footprint, and early estimates suggest that meeting de Blasio's aggressive "80 by 50" target would require the City's one million buildings to reduce emissions roughly 60% by 2050. To this end, the administration has set an interim target for the building sector of a 30% reduction by 2025, "30 by 25", while clearly outlining how improvements in building efficiency are linked to affordability, economic development, and public health.

Mayor de Blasio's ten-year housing plan, *Housing New York*, recognizes the significant rent burden experienced by city residents and outlines a plan to build or preserve 200,000 affordable housing units over the next ten years to meet the needs of over 500,000 people.[12] Part of this plan incorporates a new initiative, the Community-based Retrofit Accelerator, which aims to scale up energy and water efficiency improvements in the affordable housing sector, including small and mid-size buildings. This sector is dominated by some of New York City's most vulnerable housing stock, including New York City Housing Authority (NYCHA) and Housing Preservation and Development (HPD) properties.

One City: Built to Last clearly identifies the primary role of the building sector in meeting the City's 80 by 50 target and calls for the creation of a "Retrofit Accelerator" to drive energy efficiency retrofits in those properties required to comply with the Benchmarking and Energy Audit Laws. Using the energy use data and audit data reported from these local laws, a team of account managers will assist private sector stakeholders to determine the most effective mix of energy conservation measures and connect them with resources such as: education to understand the benefits of energy efficiency; technology demonstrations to see the results of success of successful projects; finance vehicles to support their potential projects; and engineers and contractors to implement energy efficiency retrofits.

The Retrofit Accelerator will focus on cost-effective measures that building owners can implement immediately to get NYC on the pathway to 80 by 50. To determine what other measures will be necessary, the City has convened a Technical Working Group of building industry experts to develop a road map of additional policies, programs, incentives, and mandates that will allow the building sector to meaningfully contribute to the City's 30 by 25 and 80 by 50 goals.

By driving down utility costs and reducing pollution from buildings and power plants through scaling up investment in energy efficiency, the Retrofit Accelerator will play a key role in providing affordable and sustainable housing for all New Yorkers. Of the 200,000 affordable units called for in the *Housing New York* plan, 60% are to be preserved or generated through the renovation of existing housing stock. Energy efficiency retrofits should be a significant component of any affordable housing improvement program because reductions in utility costs are felt more keenly by low-income residents.

Timing is critical. Opportunities to dramatically improve efficiency of buildings are greatest at moments of refinancing or when renovations are required by the end of useful life for a major system. In a densely developed city with a low vacancy rate, the Retrofit Accelerator is designed to ensure that smart decisions are made about upgrading existing properties at these moments.

The Retrofit Accelerator is also designed to help improve the resiliency of NYC's building stock. Following Superstorm Sandy in 2012, the Mayor's Office of Recovery & Resiliency published *A Stronger, More Resilient New York*, detailing the heavy impact of the storm and providing a road map of activities that will help NYC become more resilient in the face of anticipated climate change impacts, from storms similar to Superstorm Sandy to heat waves and droughts. Many of the neighborhoods impacted by Sandy include large swaths of affordable housing and are now subject to a variety of repair and rebuilding programs. For buildings that are located in areas at risk for flooding, the Retrofit Accelerator will connect owners and tenants with resources to help them flood-protect their buildings, electrical and heating systems, and how to provide backup power to critical loads in emergencies.[13]

NYC's ambitious carbon reduction goals align well with the New York State Energy plan, which also aims to reduce greenhouse gas emissions by 80% by 2050.[14] The 2014 plan seeks to transform the energy industry in New York State. This transformation is detailed

Reforming the Energy Vision

Reforming the Energy Vision (REV) is New York State's initiative to transform the way electricity is distributed and used in New York. This initiative aims to meet the challenges of an energy industry faced with aging infrastructure and more frequent extreme weather events by utilizing opportunities presented by increasingly innovative technology and competitive renewable resources.

The REV initiative aims to build a cleaner, more resilient, efficient, and affordable energy system through a host of regulatory changes that will each support the mission of one of REV's six focus areas: empowering customers to manage their energy use and bills, market animation, system efficiency, fuel source diversity, service reliability, and reduced carbon emissions.

Transcending market barriers and harvesting the savings identified in this report will help fulfill REV goals, addressing both New York State and City energy policy ambitions.

in the Reforming the Energy Vision (REV) proceedings (see sidebar). The plan focuses on improved energy affordability, cleaner environment through investment in clean energy, increasing system efficiency statewide, and promoting robust economic activity around the energy industry. Through such initiatives, New York continues to be a national leader in energy efficiency.

Focus of this Report

***Retrofitting Affordability* uses the newly available New York City building data to reveal where energy efficiency retrofits efforts may be targeted in order to reach climate action and affordability goals.**

As a result of the Benchmarking Law and the Energy Audit Law, NYC is collecting one of the richest data sets on building energy use in the world. In addition to the direct benefits of the retrofit measures identified within this study, it is expected that these multifamily sector findings will inform implementation of the City's climate action plan, most specifically as guidance for the Retrofit Accelerator program described above.

Retrofitting Affordability uses two primary strategies to lay the groundwork for the work of the Retrofit Accelerator within the multifamily sector. First, it identifies groups of NYC multifamily buildings with similar characteristics and collects them into market "segments." Second, it identifies the most common recommended energy conservation measures (ECMs) within each segment and outlines the anticipated energy savings, payback and carbon reductions associated with them. This catalogue of ECMs sorted by multifamily sector segments creates a list that allows building owners and property managers to better understand the likely retrofit options in their multifamily buildings based upon the recommendations made in the Local Law 87 Energy Audits. The report also looks at the location of affordable housing to identify which neighborhoods might benefit most from retrofits that improve affordability and housing quality.

As with all data analysis, the strength of any findings is based largely on the quality of the data being analyzed. In this case the analysis is based on two primary sources, data collected from the Benchmarking Law and the Energy Audit Law. The Benchmarking data includes data for 10 times as many buildings as the currently available Energy Audit data, and each set of data comes with notes of caution. The relative quality of this data, and our efforts to provide guidance within this imperfect landscape is described in the Methodology section, and in even greater detail in Appendix B, Methodology.

new york city multifamily buildings

New York City multifamily buildings are diverse in terms of size, age, fuel, construction, occupancy, and building systems. Using the available data from the City, covered multifamily buildings were divided into 12 representative segments with similar characteristics. Within these segments it is possible to identify energy savings opportunities that will apply to all properties.

Benchmarking & Energy Audit Datasets

The implementation of the Greener, Greater Buildings Plan enabled the City to collect data about energy use in large buildings, as well as detailed systems information and recommended upgrades for some buildings. The rich datasets from the Benchmarking Law and the Energy Audit Law provide the basis of the analysis for this report.

New York City's Energy Benchmarking and Disclosure Law (Local Law 84) requires all covered properties to benchmark their energy and water use data annually using the EPA's EnergyStar Portfolio Manager platform. Benchmarking data informs property owners and building managers about how much energy and water a building consumes on an annual basis and provides an easy means to compare this usage with similar properties. Property owners input the basic physical characteristics of their property (including age, size, building type, and location) into Portfolio Manager as well as their utility bills, to indicate the building's fuel use over the course of the year. Using this data, Portfolio Manager calculates the kBTU of energy per square foot, also known as energy use intensity (EUI), and uses this as a comparative metric to indicate how the building performs relative to other buildings of the same use type. Portfolio Manager also estimates the greenhouse gas emissions for all submissions, using national conversion coefficients. Since 2009, 84% of the 13,196 covered properties across all sectors have complied with this law. Roughly 70% of covered multifamily properties were compliant, representing just over 7,000 submissions annually.[15] There are now four years of Benchmarking Law data available.

New York City's Energy Audit and Retro-commissioning Law (Local Law 87) requires all covered buildings to audit their energy use and retro-commission their energy systems every ten years. A mandated energy audit provides a property owner or manager with information to better understand how a building uses its energy, and includes energy conservation measures (ECMs) recommendations, along with the projected cost, energy savings and financial impact of each ECM. The retro-commissioning required under this law are measures that tune the building's systems to make them work more efficiently as designed (see more in Impact of Retro-commissioning sidebar).

Impact of Retro-commissioning

All properties covered by the Energy Audit Law (Local Law 87) are required to "retro-commission" (RCx) their central building systems, which involves adjusting and properly maintaining the existing systems to optimize performance. The implemented retro-commissioning measures, or RCMs, must be reported to the City along with the energy conservation measures (ECMs) from the Energy Audit. RCMs are required to be implemented, while ECMs, which are typically more capital-intensive and may involve equipment replacement, are optional. Unfortunately, projected savings from RCMs were reported less systematically, and therefore were not included in the analysis in this study.

Savings from implementing RCMs, while not included in this analysis, can be significant. In a small subset of buildings where the RCM savings were reported, they ranged from $0.05 to over $1.00 per square foot. In the first Energy Audit Law project submitted to the City (by Bright Power in November 2013), a multifamily building in Brooklyn saved between 3-6% of its energy usage through implementing the RCMs alone.

Since implementation of RCMs is required, future analysis of the impact of the Energy Audit Law should include a comparison of the Benchmarking Law data at properties from the years before and after completion of the mandated retro-commissioning work from the Energy Audit Law, along with an analysis of which RCMs and ECMs as well as property types were correlated with greatest savings.

Starting in 2013, approximately 10% of the total covered building stock must submit annual audit data under the Energy Audit Law. At the time of writing, only the first year of data was available and the City has not yet made public any analysis of the data collected. *Retrofitting Affordability* uses a selection of the Energy Audit Law data to better understand the common saving opportunities identified by auditors in different types of multifamily buildings.

Methodology

The large dataset from the Benchmarking Law and the smaller dataset from Energy Audit Law are the platform from which the multifamily sector has been segmented and the basis for the development of the energy savings potential within these segments.

Identifying Energy Savings

The analysis in this report was based on Benchmarking and Energy Audit data from 2014 collected by New York City's Department of Buildings in 2013. The collected data was filtered for erroneous or improbable submissions (refer also Appendix B: Methodology).

The first phase of the analysis determined building typologies and calculated their energy usage characteristics. An empirical analysis of the data determined the most prevalent combinations of property characteristics having distinctly different profiles of recommended ECMs. The resulting 12 different building typologies are referred to as "segments." The city-wide energy usage characteristics for each segment were calculated using the Benchmarking data.

The second phase devised a methodology for analyzing Energy Audit Law data to determine a realistic projection of potential savings across all multifamily buildings. The authors analyzed the ECM submissions from the Energy Audit Law (representing 826 properties that remained after the cleaning process), taking into account the estimated cost, payback, source energy, and GHG reduction of each measure within each segment. Estimates were calculated using the frequency of the ECM recommendation and the average percentage energy savings for each measure/building type combination for multifamily buildings in the Energy Audit Law dataset. These findings from the Energy Audit data were then proportionately extrapolated to all covered multifamily buildings in NYC.[16] The results provide an estimate of the GHG reduction and the source energy savings potential within NYC's multifamily building stock from the ECMs currently being recommended by auditors of the covered buildings.

This methodology can be used in the future to refine the projections as more buildings complete Energy Audit submissions under Local Law 87 and as increasing volumes of better quality data come in every year. The study has deliberately created a replicable method of analysis so additional years of data can be analyzed with relative ease.

Calculating GHG Emissions

This report calculates GHG emissions using the regional factors from the EPA's Portfolio Manager Tool, not the City's inventory emissions calculator, which uses different coefficients for emissions and classifies large buildings differently.[17] This may attribute to some of the differences between the estimated GHG emissions; however, a deeper investigation of the relative estimation methodologies would be needed to understand this more fully. Please refer to Appendix C, Greenhouse Gas and Source Energy Conversions for more information.

Audit Data

Any methodology that utilizes Energy Audit Law data submitted to the City for Energy Audit Law compliance requires a note of caution. The authors, as well as other highly regarded energy and engineering professionals, question some of the recommendations made by energy auditors in their local law reporting, as well as the absence of some common energy conservation measures in some reports. (See sidebar: Better Guidance for Better Audits).

In preparing compliance reports, some auditors may minimize the scope of recommendations, making the estimates of potential savings quite conservative. This is supported by the analysis of the Energy Audit data that implies a total energy savings potential of 11% when implementing all applicable ECMs across all properties, whereas typical results found in other programs show 15–25% achievable cost-effective savings (and often higher predictions).[18]

Auditors may be disinclined to recommend ECMs with a long payback because it is unlikely building owners will undertake such retrofits. Additionally, many of the auditor ECM recommendations only concern the simplest or most popular measures, missing some of the more expensive or complicated opportunities which can help lay the groundwork for high-performance or net-zero buildings, for example, upgrading the envelope to meet ultra-low energy use building standards such as Passive House.

As one of the first reviews of the Energy Audit data from Local Law 87, this methodology should be seen more as a framework for the analysis of the energy audit data as it increases, rather than a definitive rulebook for energy conservation measures in NYC.

Affordable Housing in New York City

The city is home to a diverse range of incomes, in large part due to its varied affordable housing programs. In addition to the technical analysis described above, this study looks at the impacts of implementing the recommended energy conservation measures on those areas of New York City dominated by affordable housing, identified through public data sources.

The largest public housing program in the country is the New York City Housing Authority (NYCHA), operating 178,000 units. Funded by city, state and federal funds, NYCHA housing is available to those who qualify based on an application process. The wait time can be as long as 9 years. NYCHA, along with the NYC Department of Housing, Preservation and Development (HPD) administer the Section 8 program, which provides tenants with a rent subsidy to live in privately owned housing. As of 2015, federal funding for Section 8 housing is extremely limited which places additional strain on other affordable housing programs.[19] The Department of Homes and Community Renewal (HCR) administers the Low-Income Housing Tax Credit program (LIHTC) in NYC, which provides tax credits to those who invest in low-income multifamily property improvement projects.[20]

From the mid-1950s through the mid-1970s, New York City and State invested in a middle-income housing development program known as Mitchell-Lama. These buildings were privately owned rentals and co-ops that enrolled in rental assistance programs in return for tax incentives and subsidies. Landlords and co-op boards were given the option to opt-out after 20 years and bring their apartment rents up to market rate if the building did not renew

Table 1: Subsidized and Unsubsidized Housing Units in NYC, 2011[22]

Housing Type	Category	No. of units
Subsidized Housing		
	Public Housing (NYC Housing Authority)	**178,017**
	Section 8 Vouchers	**123,843**
	HUD Project-based Rental Assistance*	**82,981**
	Low Income Housing Tax Credits (LIHTC)*	**75,076**
	Mitchell-Lama Co-ops*	**65,612**
	HUD Financing or Insurance*	**40,701**
	Other Mitchell-Lama	**33,680**
	Total: Subsidized	599,910
Non-Subsidized Housing		
	Market Rate	**722,650**
	Rent Control	**1,063,148**
	Total: Non-Subsidized	1,785,798
Total	Subsidized + Non-Subsidized	2,385,708

* Included in the SHIP dataset
(Source: NYU Furman Center, *State of New York City's Subsidized Housing*: 2011)

their tax-incentive contract. 55% have left the program as of 2011.[21] Lastly, rent control and rent stabilization, while not technically housing subsidies, provide the largest number of rent regulated units, many of which are affordable for low and middle income New Yorkers. The breakdown of the subsidized and unsubsidized housing types can be seen in Table 1.

Target affordability areas were determined by overlaying the segments and the analysis of conservation measures with data from the US Census American Community Survey (ACS) and Furman Center for Real Estate and Urban Policy at New York University. ACS data provided median household income and median gross rent burden by zip code. The Furman Center provided specific property data regarding subsidized housing in New York City. For this study, "affordable" housing is defined as properties in the New York City Housing Preservation and Development (HPD), the Housing Development Corporation (HDC), and the NYCHA portfolios. This does not include rent-controlled or rent-stabilized apartments.

The affordability data was married with the technical analysis of the multifamily segments described earlier, to identify areas where there is both a high proportion of affordable housing and a high proportion of buildings with significant energy savings potential.

Housing Stock Attributes – The Segments

Segmenting multifamily buildings based on specific characteristics allows for a high level comparison of energy savings opportunities across the entire sector.

Multifamily Characteristics

Based on the Benchmarking Law data three physical characteristics were chosen to divide New York City multifamily properties into segments: age, height, and primary heating fuel.[23] These characteristics are described at right and outlined in Table 2. The "segments" were selected to capture not just properties that use energy differently but properties whose energy efficiency solutions would differ substantially. For instance, as in many similar studies, the authors found no strong correlation between building age and energy efficiency. However, the study divides Pre- and Post-war properties because the measures recommended to improve them are different due to substantial differences in construction and systems. Since it was not possible to extrapolate the heating system type from the data, age and height are used as a proxy for heating system.

Comparing Benchmarking Law and Energy Audit Law Submissions

The Benchmarking Law and the Energy Audit Law datasets (Figure 5) show similar ratios of property characteristics (e.g. a similar percentage of Post-war vs. Pre-war buildings). Therefore, the authors felt comfortable extrapolating findings of the Energy Audit reporting to all multifamily properties in the Benchmarking dataset.

The Segments

From the many possible combinations of age, height, and heating fuel, 12 multifamily sector segments were delineated, representing more than 95% of the covered multifamily property area (see Appendix B: Methodology). Table 3 outlines these 12 segments, and their primary properties, including energy use and carbon emissions, extrapolated to all covered multifamily buildings.

To determine the total source energy and carbon emissions of each segment, the authors extrapolated from the cleaned 2014 Benchmarking data (7,731 properties) to all covered multifamily properties (10,043 properties). These extrapolated numbers are used throughout all of the charts and tables of this report. From this calculation, large multifamily properties represent ~193 Tera BTUs (TBTU, or 10^{12} BTU) or 203 million gigajoules (GJ) of source energy use. This is comparable to the *2014 Inventory of New York City's Greenhouse Gas Emissions* report estimate of 182.9 million gigajoules for “Residential Large” buildings. In terms of carbon emissions, this analysis estimates that all multifamily segments produce 9.24 million metric tons carbon dioxide equivalent (MMTCO2e), equal to the City’s 2014 estimate of 9.2 MMTCO2e for “Residential Large” buildings (see Appendix C for further details).

Area for each segment tracks closely with source energy use, as seen in Table 3, but does not correlate as closely with number of properties. This analysis uses the square footage of each segment in order to assess its impact rather than the number of properties, because the size of properties (and therefore the

Large Multifamily Characteristics

Age Pre- and Post-war properties include significantly different construction materials and typically include different types of energy using systems.

Pre-war
Properties built before 1947. These buildings have shallower floor plates, and were generally built without central ventilation systems or central air conditioning. For heating, they typically have radiators with 1-pipe or 2-pipe steam distribution.

Post-war
Properties built in 1947 and later. These generally have bigger windows and may also have central ventilation and central cooling systems. The heating distribution system is more varied, and may include electric, forced air, hydronic, heat pumps and vacuum 2-pipe steam.

Height The height of buildings is a broad indicator of construction type and energy savings opportunities. For example, the tallest buildings tend to have more opportunities for controlling airflow in elevator shafts, trash chutes, and ventilation systems; while shorter buildings have a higher ratio of envelope to floor area.

Low-rise
7 or fewer floors above grade.

Mid-rise
8–19 floors.

High-rise
20 or more floors.

Primary Heating Fuel The type of heating fuel directly impacts the types of conservation measures under consideration. There are four heating fuel categories.

Electric
Properties that use electricity as their primary heating fuel are typically Post-war construction.

Gas
Natural gas is used as a primary heating fuel in buildings of all heights and vintage.

Oil
Includes all oil grades; cleaner and lighter #2 heating oil, as well as the heavier and dirtier #4 and #6 heating oils. As of September 2015, the majority of #6 oil heated buildings have converted to cleaner fuels. (See Clean Heat Sidebar)

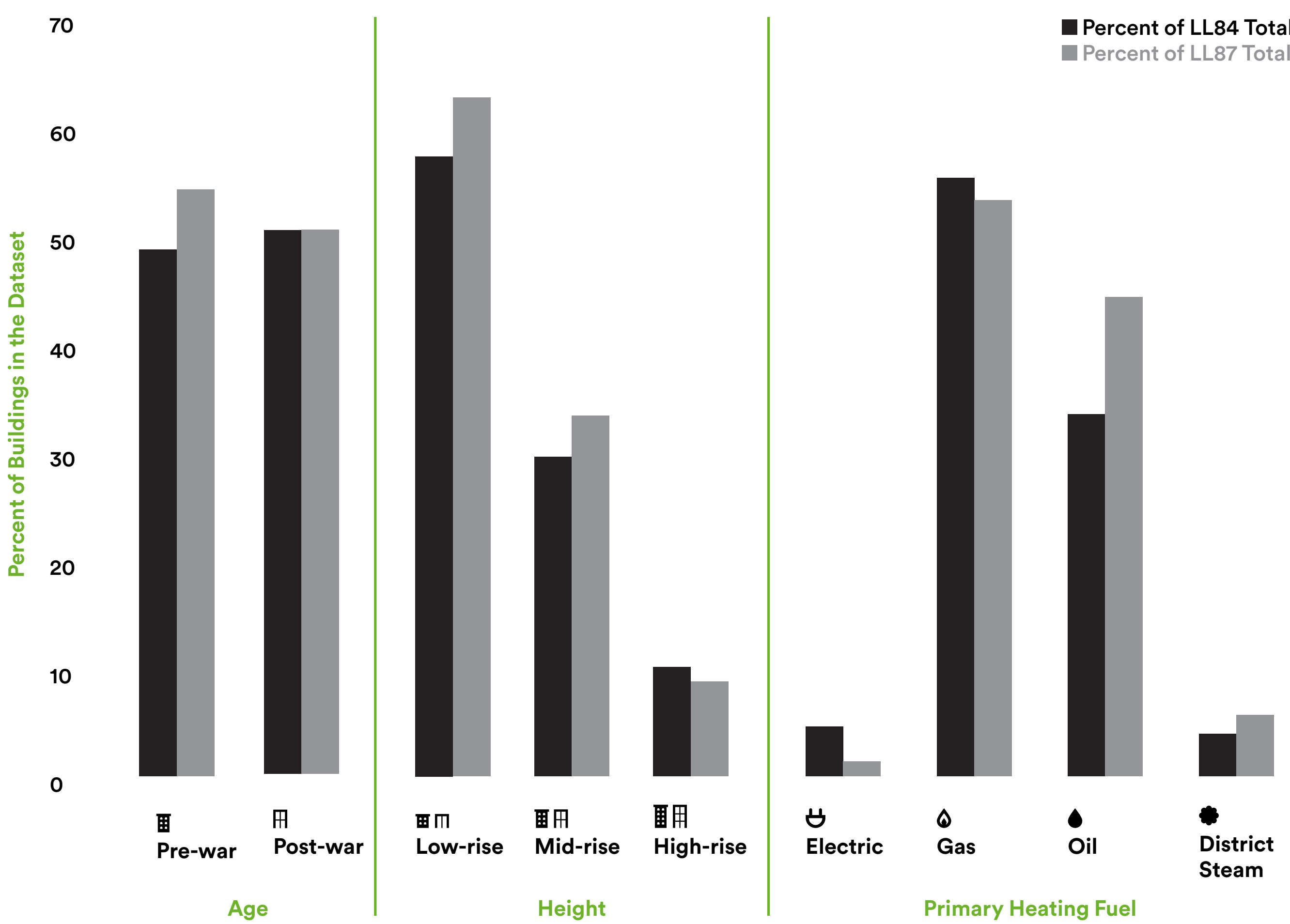
District Steam
Provided by Consolidated Edison, and is only available in parts of Manhattan.

Table 2: Covered Multifamily Buildings Characteristics*

Characteristic	Type	Number of Properties	Percent of Properties	Area (Million SF)	Percent of Area
Age	Pre-war	4,920	49%	510	33%
	Post-war	5,123	51%	1,050	67%
	Total	10,043	100%	1,550	100%
Height	Low-rise	5,869	58%	640	41%
	Mid-rise	3,046	30%	520	33%
	High-rise	1,128	11%	400	26%
	Total	10,043	100%	1,550	100%
Heating Fuel**	Electric	537	5%	70	5%
	Gas	5,644	56%	940	60%
	Oil	3,450	34%	440	28%
	District Steam	412	4%	100	6%
	Total	10,043	100%	1,550	100%

*Dual fuel buildings were classified based on the primary fuel that used the most energy.

Figure 5: Comparison of LL84 and LL87 Property Characteristics

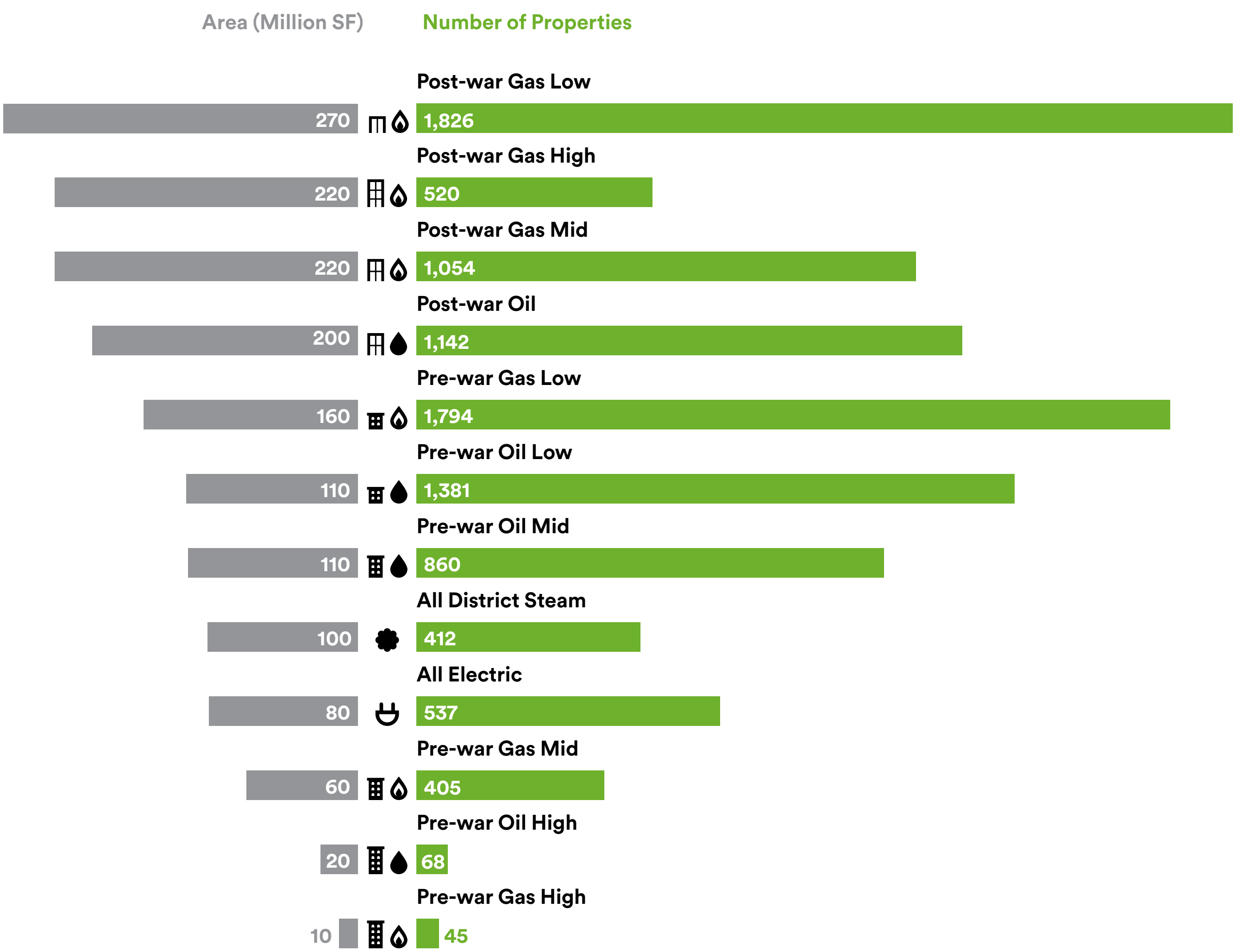


The proportion of each building characteristic was similar across LL84 and LL87. Therefore, this report extrapolates the findings from the LL87 data to the entire covered multifamily building stock.

Table 3: Characteristics of Multifamily Segments

Segment	Number of Properties	Percent of Total Properties	Area (Million SF)	Percent of Total Area	Source Energy Use (TBTU)	Percent of Total Source Energy Use	GHG Emissions (MMT-CO2e)	Percent of GHG Emissions
Post-war Gas Low	1,826	18%	270	17%	31	16%	1.6	17%
Post-war Gas High	520	5%	220	14%	35	18%	1.4	15%
Post-war Gas Mid	1,054	10%	220	14%	26	13%	1.2	13%
Post-war Oil	1,142	11%	200	13%	26	13%	1.4	15%
Pre-war Gas Low	1,794	18%	160	10%	17	9%	0.8	9%
Pre-war Oil Low	1,381	14%	110	7%	13	7%	0.8	9%
Pre-war Oil Mid	860	9%	110	7%	12	6%	0.6	7%
All District Steam	412	4%	100	6%	15	8%	0.7	7%
All Electric	537	5%	80	5%	8	4%	0.2	2%
Pre-war Gas Mid	405	4%	60	4%	6	3%	0.3	3%
Pre-war Oil High	68	1%	20	1%	2	1%	0.1	1%
Pre-war Gas High	45	0%	10	1%	2	1%	0.1	1%
Total	10,043	100%	1,550	100%	192.7	100%	9.2	100%

Figure 6: Comparison of Total Area and Number of Properties in Multifamily Segments



From this comparison of the area and the number of properties, it is clear to see that they do not always correlate. Therefore, this study uses area to assess the potential energy impacts of each segment.

Map 2: Segment with Greatest Floor Area by Community District

Legend
Segments

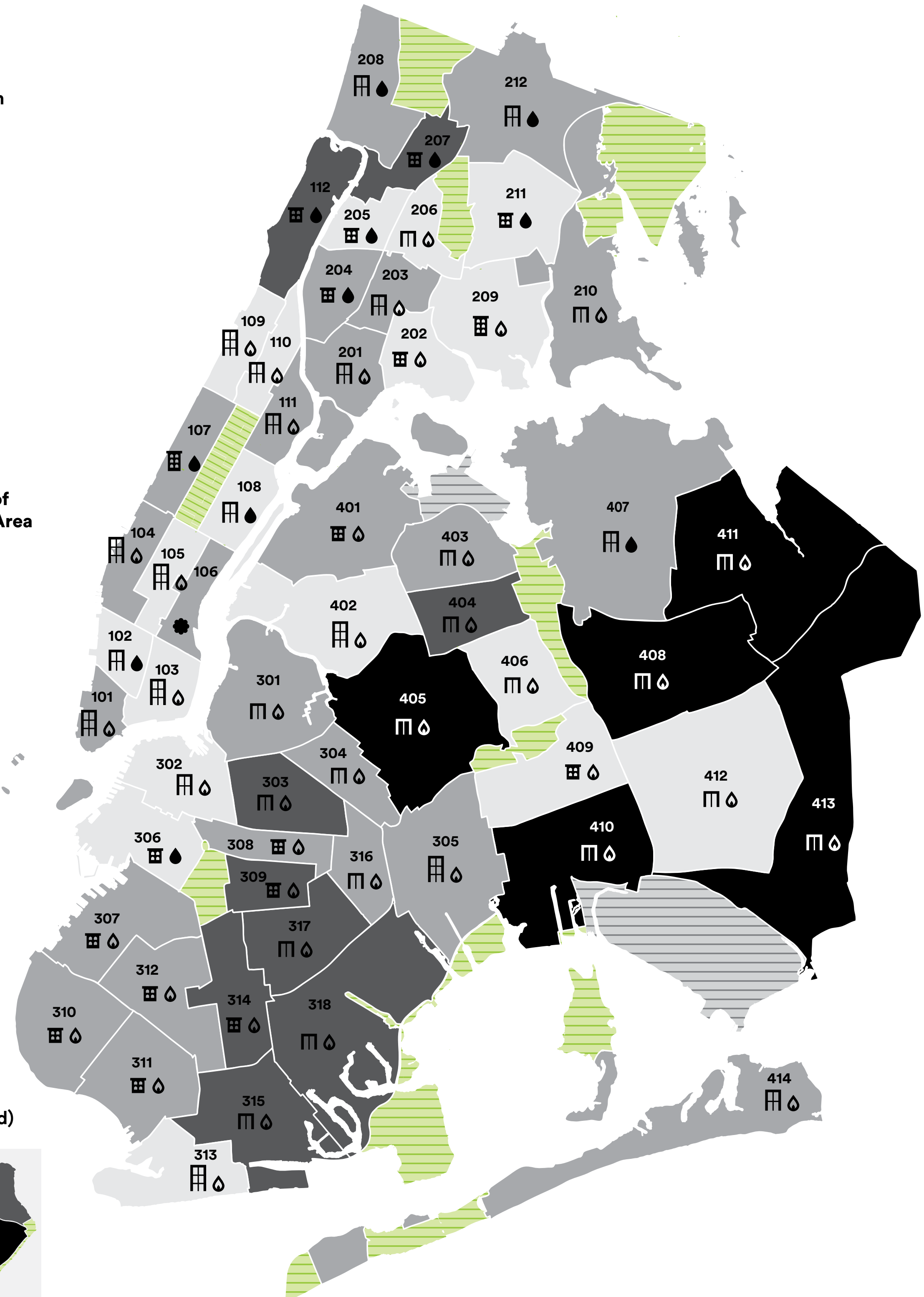
- All District Steam
- Post-war Gas High
- Pre-war Gas High
- Post-war Gas Mid
- Pre-war Gas Mid
- Post-war Gas Low
- Pre-war Gas Low
- Post-war Oil
- Pre-war Oil High
- Pre-war Oil Mid
- Pre-war Oil Low
- All Electric

Legend

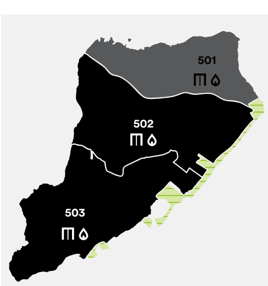
- Parks
- Airport

Segment as Percent of Community District Area

- 0%–35%
- 35.1%–45%
- 45.1%–60%
- 60.1%–90%



Staten Island (reduced)



Map 2 shows the icon of the segment with the greatest square footage in the community district. Community districts that are shaded lighter have a greater diversity of building segments, compared to those that are shaded darker. This can help identify areas to target based on segment focus.

Photo: Brad Clinesmith

energy use) can differ significantly (see Figure 6).

Map 2, Segment with Greatest Floor Area by Community District, shows the icon of the segment with the greatest square footage in each community district. The shading shows the percentage of square footage represented by the biggest segment of all covered multifamily buildings in each community district. For example, the Ridgewood/Maspeth neighborhood in Queens (CD 405) is dominated by Post-war Gas Low-rise buildings comprising over 60% of the square footage. However, most other community districts have a greater diversity of building types. For instance, on the Upper East Side (CD 108) Post-war Oil Mid-rise buildings have the greatest square footage, but represent less than 35% of all its square footage. This map identifies areas that may benefit from a "package" of ECMs for the biggest segment in the district.

Implementing all of the energy conservation measures recommended within the Energy Audit Law reporting across the entire New York City stock of large multifamily buildings would produce significant greenhouse gas reductions and energy savings and is an important step on the path to greater impacts.

This study finds the implementation of all of the recommended energy conservation measures would reduce the GHG emissions of all covered multifamily buildings in New York City by 11%. These retrofits, reducing the energy use NYC's large multifamily buildings by 11%, would cost approximately $2.1 billion and would save over $350 million annually. Taken together, these measures represent a GHG reduction of 1.03 MMTCO2e and 20.9 TBTU of energy savings.

More than half (53%) of the potential energy savings identified in the Energy Audit data is achievable with ECMs that have paybacks of less than five years (see Table 9). An additional 26% of the potential source energy savings is achievable with ECMs that have paybacks of less than ten years. If implemented, these ECMs would contribute significantly toward the City's interim climate action plan goal of a 30% reduction by 2025.

Savings by Multifamily Segments

Each of the segments of multifamily housing types, and their respective recommended energy conservation measures, were analyzed from several perspectives to identify the most impactful and effective source energy savings and carbon emissions reductions.

The study first breaks down the potential contribution of source energy savings and greenhouse gas reductions to citywide savings from each segment (Table 5). The study also analyses the costs and financial benefits of the various ECMs, as well as the potential energy savings and carbon reductions for each measure within each segment.[24]

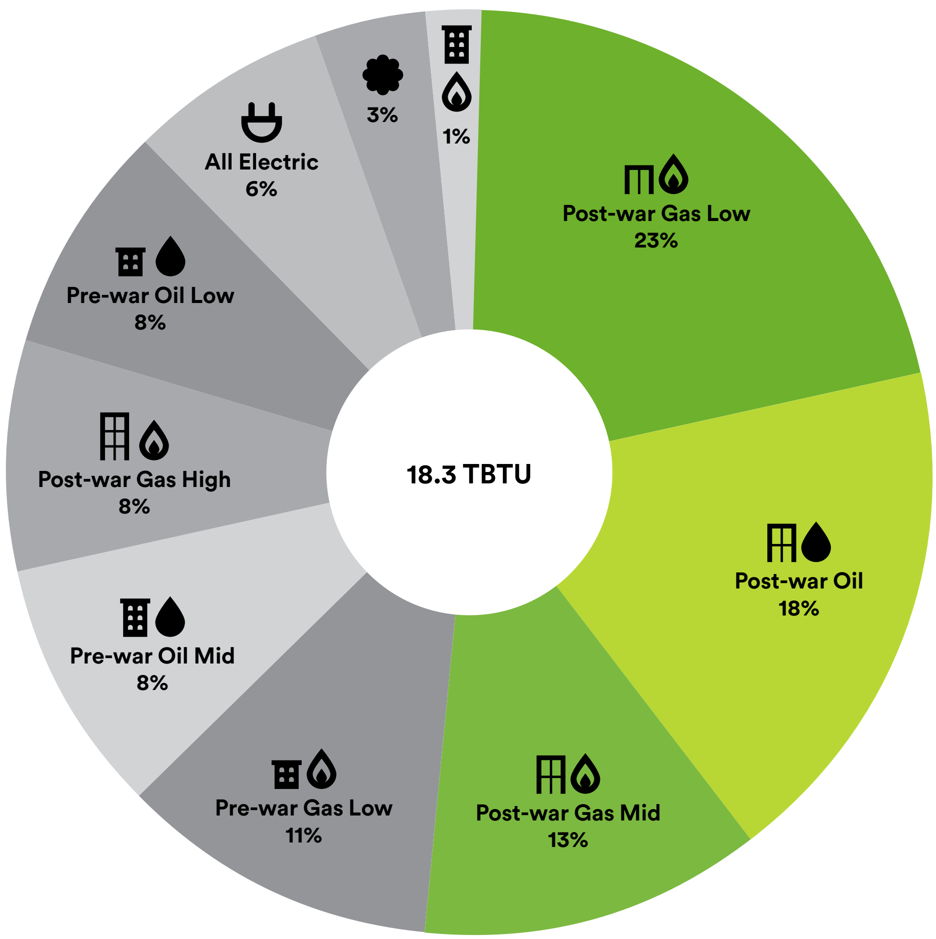
A number of striking details reveal themselves. Citywide, 54% of the potential source energy savings and 57% of the potential carbon reduction comes from Post-war Gas Low-rise, Post-war Oil, and Post-war Gas Mid-rise properties (see Figure 7). The relative savings impact of these three segments is significant. Though these segments are three of the four biggest users of source energy currently, they represent only 44% of the floor area and 41% of the citywide cost of implementing all ECMs (See Table 5).

Table 4: Contribution of Potential Source Energy Savings by Segment

Segment*	Source Energy Potential Savings (TBTU)	Percent of Total Potential Source Energy Savings	Total GHG Potential Reductions (MMT-CO2e)	Percent of Total GHG Potential Reduction	Retrofit Cost (Million $)	Percent of Total Cost	Payback (years)
Post-war Gas Low	4.9	23%	0.25	24%	$230	11%	6.8
Post-war Oil	3.7	18%	0.20	20%	$430	20%	4.8
Post-war Gas Mid	2.7	13%	0.13	13%	$220	10%	5.4
Pre-war Gas Low	2.3	11%	0.11	11%	$180	8%	7.7
Pre-war Oil Mid	1.7	8%	0.10	10%	$240	11%	4.8
Post-war Gas High	1.7	8%	0.07	7%	$40	2%	4.2
Pre-war Oil Low	1.7	8%	0.10	10%	$280	13%	5.0
All Electric	1.2	6%	0.03	3%	$500	23%	10.4
All District Steam	0.7	3%	0.03	3%	$50	2%	4.1
Pre-war Gas Mid	0.3	1%	0.01	1%	$10	1%	4.6
Total	20.9	100%	1.03	100%	$2,180	100%	5.9

*Pre-war High-rise buildings were omitted from this analysis because there was not a representative sample in LL87 data.

Figure 7: Potential Source Energy Savings by Segment



This chart shows the contribution of each segment to the overall source energy savings (18.3 TBTU) that can be achieved if all ECMs are implemented. Post-war Oil, Post-war Gas Low-rise and Post-war Gas Mid-rise represent the segments with the biggest potential energy savings. See Figure 8 for the depth of savings within each segment.

Better Guidance for Better Audits

While reducing the energy use of all large multifamily buildings by 11% would be a substantial accomplishment, and a strong first step towards New York City's climate action goals, it is likely that significantly more savings are available on individual projects.

Many industry experts, including the authors and some members of the technical advisory group, have questioned the quality of the auditing work that is the basis for the study. There are indications of both under-reporting of the effectiveness of certain measures (especially heating system improvements) as well as over-reporting of others (such as domestic hot water replacements). Additionally, there is anecdotal evidence that a number of inexperienced individuals were tasked with performing audits for organizations who viewed them as merely a compliance task and not an opportunity to improve their buildings.

Meanwhile, most professionals with significant experience in multifamily retrofits find significantly more savings on most projects than are indicated in the audit data. The City, in particular the Department of Buildings, MOS, and perhaps in concert with NYSERDA, could combat this by providing more guidance about which measures are most effective under which circumstances, perhaps even using the segments developed here as a framework.

This guidance might invite auditors to include a greater focus on the largest energy end uses within NYC's existing multifamily buildings, especially central heating systems. A whole systems approach to HVAC upgrades and controls, such as a combination of system balancing, boiler controls, and temperature sensors throughout the building will lead to greater total savings than each of these measures on their own. This comprehensive approach would also promote exterior insulation and airtightness improvements to reduce heating and cooling demands, in an approach similar to the Passive House standard discussed elsewhere in this study.

Since they are optional, only a limited number of owners have proceeded with the recommendations within their Energy Audit Law reports. A more holistic approach to energy conservation and initiatives like the Retrofit Accelerator will be critical to substantially increase the uptake and scale of energy retrofits and ensure that we are on a clear pathway to the goal of reducing our carbon footprint 80% by 2050.

As seen in Table 4, percent of source energy savings tracks closely with percent of greenhouse gas reduction. Therefore, in understanding this analysis, energy savings and greenhouse gas reduction can effectively be used interchangeably.

The savings opportunity was similar when looking at depth of potential savings from each segment (Table 5). Post-war Gas Low-rise and All Electric properties had the greatest depth of potential source energy reduction (16% each), followed by Post-war Oil (14%). The percent potential depth of carbon reduction follows a similar trend. This analysis reinforces that Post-war Oil and Post-war Gas properties represent the biggest potential source energy savings and carbon reduction opportunities, both citywide and within the segments.

The All Electric segment stands out on both Tables 4 and 5. First, while this segment represents 6% of potential source energy savings, it only represents 3% of potential GHG reductions. This is due to the relative efficiency of electricity generation and distribution infrastructure. Second, the ECMs for All Electric buildings are quite expensive, representing 23% of the total costs across all large multifamily buildings in NYC. Thus, if the goal is cost-effective carbon reduction, the City should not focus on All Electric buildings because they are an expensive investment for a relatively small return.

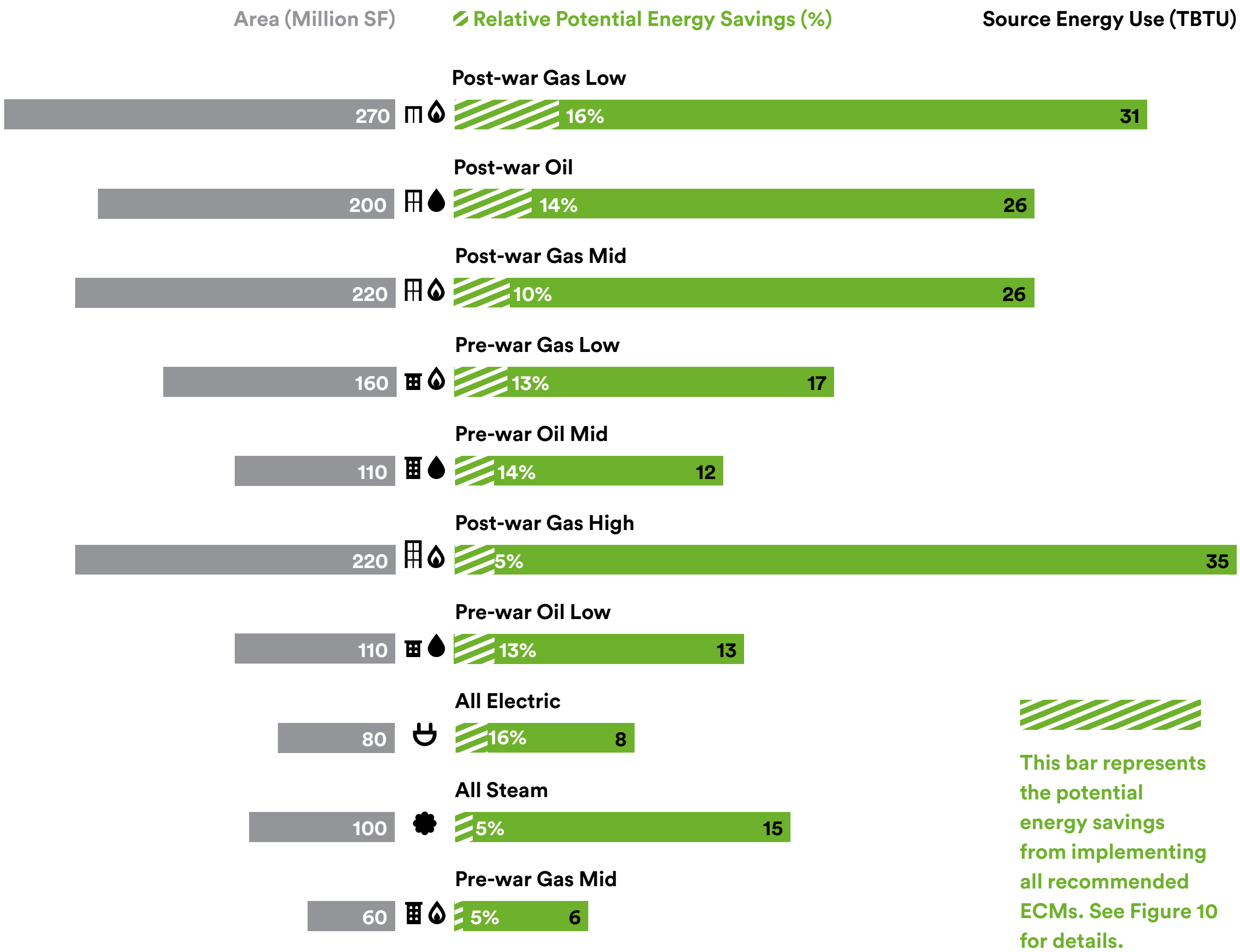
In addition to source energy savings and carbon reduction potential, it is important to consider retrofit cost and payback. The three segments with the largest potential source energy savings (Post-war Gas Low-rise, Post-war Oil, and Post-war Gas Mid-rise) have a payback of less than 7 years. These three segments should be the first targets of the City's plan to retrofit buildings and reduce carbon emissions.

Each segment has a different energy savings opportunity. In general, oil properties have a shorter payback, when compared to gas properties. Gas prices are currently lower than oil prices, which drives longer paybacks in gas-heated buildings for the same ECMs discussed below. A detailed list of each segment's ECMs and their potential source energy savings and their estimated paybacks can be found in the Appendix, Tables 13 and 14.

Table 5: Depth of Savings Potential within Each Segment

Segment	Current Source Energy Use (TBTU)	Potential Source Energy Savings (TBTU)	Percent Source Energy Reduction	Current GHG Emissions (MMT-CO2e)	GHG Potential Reduction (MMT-CO2e)	Percent GHG Potential Reduction	Retrofit cost (Million $)	Cost per TBTU (Million $ TBTU)
Post-war Gas Low	31	4.9	16%	1.59	0.25	16%	$230	$50
Post-war Oil	26	3.7	14%	1.39	0.20	14%	$430	$120
Post-war Gas Mid	26	2.7	10%	1.24	0.13	11%	$220	$80
Pre-war Gas Low	17	2.3	13%	0.85	0.11	13%	$180	$80
Pre-war Oil Mid	12	1.7	14%	0.62	0.09	14%	$240	$140
Post-war Gas High	35	1.7	5%	1.38	0.07	5%	$40	$20
Pre-war Oil Low	13	1.7	13%	0.80	0.10	13%	$280	$170
All Electric	8	1.2	16%	0.20	0.03	16%	$500	$410
All District Steam	15	0.7	5%	0.69	0.03	5%	$50	$80
Pre-war Gas Mid	6	0.3	5%	0.31	0.01	4%	$10	$50
Total	193	20.9	11%	9.24	1.03	11%	$2,180	$100

Figure 8: Comparison of Area and Source Energy by Segment



This graphic compares the relative proportion and magnitude of ECMs recommended for each building segment. The savings from implementing all these ECMs as a proportion of each segment's total source energy is shown in Figure 10.

Energy Conservation Measure Categories ECMs are a required part of the Energy Audit Law audit. On the submission form, auditors can submit measures under 15 different categories. For the purposes of simplification in this report, these 15 categories were condensed to 7 categories to show significant energy savings opportunities for different building systems.

Domestic Hot Water

Building Envelope

Fuel Switching

Heating & Distribution

Lighting

Ventilation & Cooling

Other

Individual measures in each category can be found in the appendix tables. The savings potential for each category is shown below in Table 6.

Savings by Energy Conservation Measures

Exploring the energy conservation measures recommended across all covered multifamily buildings allows a more granular view of the effectiveness, cost and payback of the various steps required to improve the performance of this critical sector.

Energy Conservation Measure Categories

A key component of each Energy Audit Law submission is a list of recommended energy conservation measures (ECMs). Auditors can submit ECMs to the City under fifteen different categories, which in this report were condensed to seven. These categories are: domestic hot water, building envelope, fuel switching, heating and distribution, lighting, ventilation and cooling, and other. The ECMs in the Energy Audit Law submissions for each segment were analyzed and then scaled up to represent the total savings potential for all large NYC multifamily buildings in each measure category, as shown in Table 6.

The opportunities for each ECM category is based on the recommendations of the auditors. According to the data, the categories representing the biggest opportunity, Domestic Hot Water (DHW) and Heating & Distribution, represent 66% of the potential source energy savings recognized by the Local Law 87 auditors. The average cost per square foot of Heating & Distribution measures is $0.41, whereas the average cost per square foot for DHW measures is only $0.18. Each category has about a 4-year average payback. All together, these measures represent only about 25% of the total citywide cost of implementing all of the ECMs recommended in LL87.

Since heating usually consumes the most fuel in a multifamily property, it aligned with our expectations that measures in the Heating & Distribution categories had the greatest energy savings. However, some of the other findings in the data were surprising (see Better Guidance for Better Audits sidebar). For example, though separating heating from domestic hot water was frequently recommended, the experienced auditors reviewing this report do not believe that this is as widely applicable or effective.

Lighting, including switching to LEDs and high-efficiency fluorescents, was the most frequently recommended ECM category. Lighting retrofits in the multifamily sector may become more widely adopted, as they are relatively inexpensive ($0.06/SF), have a 6-year payback, and are very easy to see by owners and tenants alike. Though lighting

Table 6: Potential Source Energy Savings by ECM Category

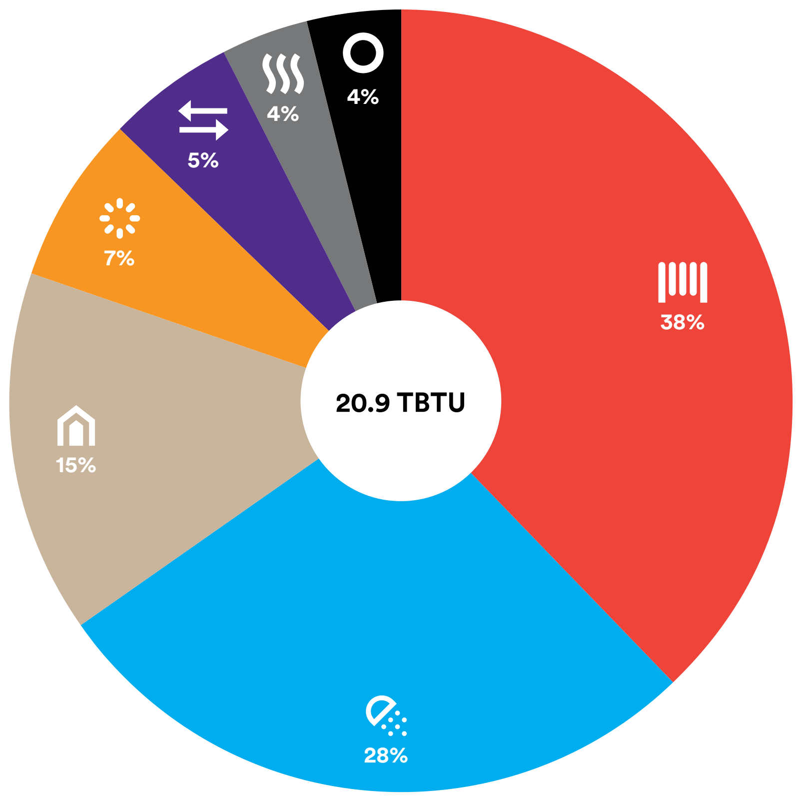
Category	Source Energy Potential Savings (TBTU)	Percent of Total Source Energy Potential Savings	GHG Potential Reduction (MMT-CO2e)	Percent of Total GHG Emissions Reduction Potential	Total Citywide Cost (Million $)	Percent of Citywide Cost	Payback (Years)
Heating & Distribution	7.9	38%	0.40	39%	$350	16%	4
Domestic Hot Water	5.8	28%	0.28	27%	$240	11%	4
Envelope	3.1	15%	0.15	15%	$750	34%	17
Lighting	1.5	7%	0.07	7%	$330	15%	6
Fuel Switching	1.1	5%	0.06	6%	$350	16%	4
Ventilation & Cooling	0.8	4%	0.04	4%	$60	3%	9
Other	0.8	4%	0.03	3%	$110	5%	4
Total	20.9	100%	1.03	100%	$2,180	100%	6

represents only 7% of potential citywide source energy savings, it may be an "easy win" that can help pave the way for more intensive measures.

ECMs that have a long payback but are recognized to have a large impact on energy savings were also underrepresented. Envelope measures such as upgrading a building's exterior insulation can yield significant energy use reductions and represent 15% of the potential citywide source energy savings from the Energy Audit data. However, these measures are more expensive, costing on average $0.65 per square foot, and have a calculated payback of 17 years.

Though Fuel Switching only represented 5% of potential savings across all covered multifamily properties, it constitutes 15% of the potential source energy savings for properties that use oil as their primary heating fuel. Fuel switching occurs when properties convert their primary heating fuel from #6 heating oil to #2 heating oil or natural gas. (For more specific information, see the Clean Heat sidebar.) Due to data availability, all types of heating oil (#2, #4, #6) were combined into one segment. In all of the properties using oil as the primary heating fuel in the Energy Audit Law submissions, fuel switching was recommended

Figure 9: Potential Source Energy Savings by ECM Category



This chart shows how each ECM category contributed to the total source energy savings identified by the Energy Audit submissions.

Passive House

Passive House is a rigorous standard leading to very comfortable buildings that use vastly less energy than conventional projects. This standard has been successfully applied in all climates and to myriad building types using thoughtful construction based on specific fundamentals. Unlike US energy codes, which focus on the predicted performance of buildings, the Passive House standard includes caps on actual energy use. More than 20 years of building science research has confirmed the key elements that virtually guarantee the highest quality interior environment with the most cost-effective energy use, including:

- **Highly insulated envelopes: Insulation is 3-5 times standard construction**
- **Airtight construction: Allowable infiltration is 10 times as stringent as standard construction**
- **Thermal break free design: Common thermal bridges like exposed slab edges are eliminated**
- **High performance windows and doors: Triple-pane glazing with insulated frames are required**
- **Continuous ventilation, with energy recovery: Efficient delivery of consistent fresh air is critical to comfort**

Taken together, these principles provide a high performance enclosure that needs minimal heating or cooling to maintain a very comfortable interior. While some components such as triple-glazed windows are more expensive, costs are recouped through far lower energy and maintenance costs and smaller heating and cooling systems. Additionally, the standard leads to investment in long-life building components (insulation, tight construction, high quality windows) rather than mechanical and control systems that require frequent refurbishment and whose performance degrades significantly over their useful life.

With 20,000 buildings certified around the world, the broad adoption of Passive House does not present technical challenges. The barriers are cultural in nature, requiring the education of all building industry stakeholders to take a different approach to high-performance buildings and to work as a team to deliver them.

To learn more about Passive House visit: http://bit.ly/1GqoSTD

for 19% of properties. If all ECMs were implemented in all covered multifamily buildings in NYC, fuel switching would account for 5% of potential source energy savings (1.08 TBTU) and 6% of greenhouse gas potential reduction savings (0.06 MMTCO2e), though it would be 16% of citywide costs ($357 million). Converting from #4 or #6 heating oil to natural gas was the most frequently recommended fuel switching measure (65%). Though heating oil conversions are an important emissions mitigation strategy in the short term, it is important to keep in mind that this, too, is a transitional technology as NYC moves toward lower carbon fuel sources, such as electric heat pumps from renewable sources.

By combining ECM categories with segments, it is possible to see which types of ECMs have the biggest potential source energy savings for each property type. Figure 10, right, shows the savings impact of each ECM for each segment. This chart can help guide property owners and city planners to where they should invest their efforts when performing retrofits. For example: on a citywide scale, implementing Heating & Distribution ECMs in Post-war Gas Low-rise properties will result in larger savings than doing all of the ECMs in Pre-war Gas Mid-rise properties combined. On a property level, in Post-war Oil properties, targeting Domestic Hot Water ECMs has the potential to save significantly more source energy than Ventilation & Cooling ECMs.

Individual ECMs

From the analysis of the auditors' submissions, it is possible to see many characteristics of the ECMs recommended for each segment, including: frequency, cost per square foot, potential source energy savings, potential GHG reduction, payback, and citywide cost.

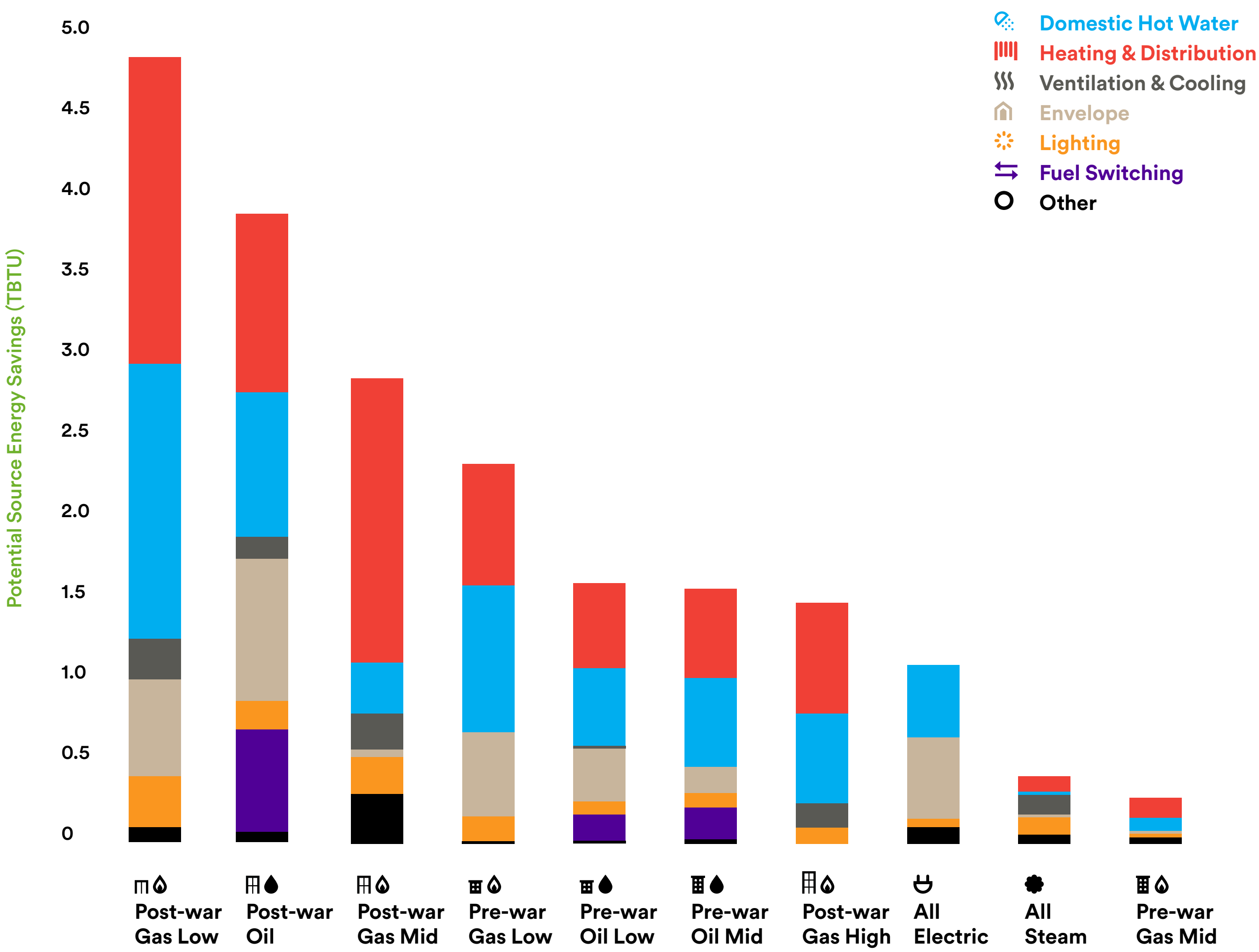
Reviewing the ECMs without the context of the segments or categories, other significant opportunities become apparent (See Table 7). Out of the 75 different types of ECMs recommended across the city in the cleaned Energy Audit Law dataset, five specific ECMs represent 46% of the potential energy savings across all large multifamily properties. Though these measures vary from very straightforward (insulate pipes) to more difficult (replace windows), they show that auditors estimate significant savings from both large and small retrofits. However, it is more likely that simpler retrofits will be completed first, as they have a shorter payback and require significantly less time and investment on behalf of the property owner and manager.

Table 8 shows the ECMs with the biggest energy savings potential for the segments with the greatest opportunity. Similar to the citywide ECM category analysis, measures that fall under Domestic Hot Water and Heating & Distribution categories have the greatest potential source energy savings. In Post-war Oil properties, fuel switching is also highly recommended. If just these 15 measures were applied across Post-war Gas Low-rise, Post-war Oil, and Post-war Gas Mid-rise buildings, there is a potential source energy savings of 31% from all covered multifamily properties, and potential GHG reduction of 32% from all covered multifamily properties using only 20% of citywide costs to implement all the Energy Audit Law recommended measures. A full list of ECMs with the greatest energy savings potential by segment and by category can be found in Appendix Tables 12 and 13.

Payback

Payback was also a key part of the analysis (see Table 9, Figure 11). According to the Energy Audit data, 53% of the potential source energy savings opportunity can be achieved through measures

Figure 10: Potential Source Energy Savings for Each Segment by ECM Category



This graphic shows how each segment can achieve its potential source energy reduction (as seen in Figure 8), as part of all of the energy reductions (as seen in Figure 7). The potential source energy savings of each ECM category can be compared across each segment.

Table 7: Five Energy Conservation Measures with Greatest Potential Source Energy Savings

Measure	Source Energy Potential Savings (TBTU)	Percent of Total Source Energy Potential Savings	GHG Potential Reduction (MMT-CO2e)	Percent of Total GHG Potential Reduction	Total Cost (Million $)	Percent of Citywide Cost	Payback (Years)
Seperate DHW from Heating	3.0	14%	0.15	15%	$150	7%	6
Install or Upgrade EMS/BMS	2.8	13%	0.14	13%	$40	2%	2
Replace Windows	1.5	7%	0.07	6%	$530	24%	18
Total Lighting Retrofit*	1.5	7%	0.07	7%	$330	15%	6
Insulate Pipes	0.9	4%	0.04	4%	$10	1%	2
Total Top 5	9.7	46%	0.47	46%	$1,060	49%	

*This is all recommended lighting measures, to indicate the energy savings opportunity of a lighting retrofit.

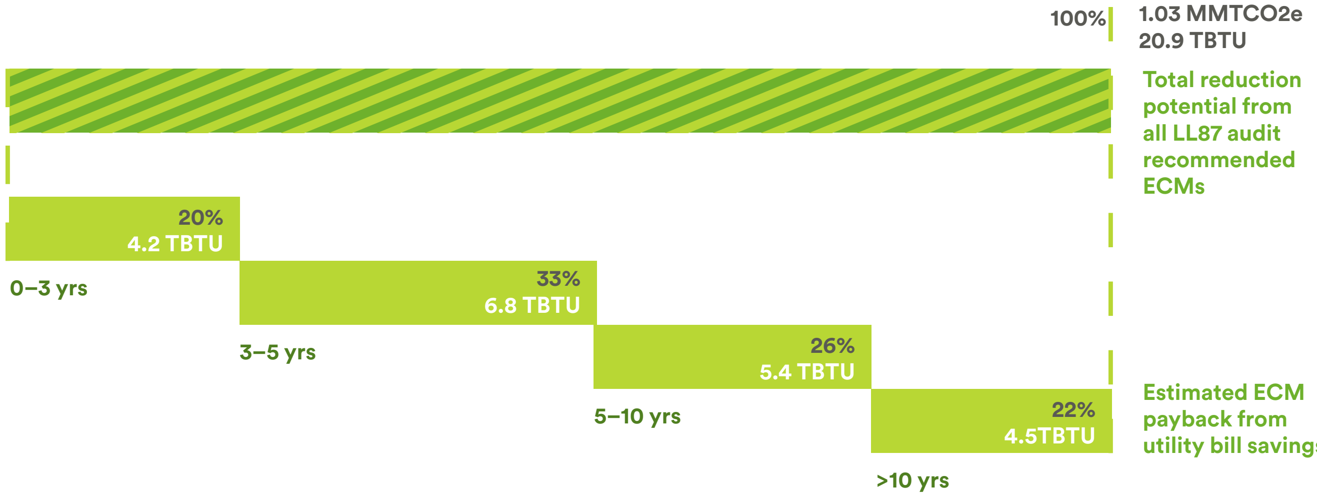
Table 8: ECMs with the Greatest Potential Source Energy Savings in the Three Largest Segments

	Source Energy Potential Savings (TBTU)	GHG Potential Reduction (MMTCO2e)	Citywide Cost (Million $)	Payback (Years)
Post-war Gas Low				
Domestic Hot Water: *Separate DHW from Heating*	1.0	0.05	$24	5.8
HVAC Controls & Sensors: *Install or Upgrade EMS/BMS*	0.6	0.03	$9	2.4
Domestic Hot Water: *Install Low-Flow Aerators*	0.5	0.03	$4	1.1
Heating System: *Upgrade Burner*	0.4	0.02	$11	6.4
Heating System: *Replace Boiler*	0.2	0.01	$7	13.2
Total	2.7	0.14	$55	
Post-war Oil				
Fuel Switching: *#6 oil or #4 oil to natural gas*	0.6	0.03	$97	3.1
Domestic Hot Water: *Separate DHW from Heating*	0.6	0.03	$28	4.2
Envelope: *Replace Windows*	0.5	0.03	$147	16.7
HVAC Controls & Sensors: *Install or Upgrade EMS/BMS*	0.4	0.02	$5	1.4
Domestic Hot Water: *Install Low-Flow Aerators*	0.2	0.01	$2	0.6
Total	2.2	0.12	$279	
Post-war Gas Mid				
Heating System: *Other*	0.8	0.04	$52	4.5
HVAC Controls & Sensors: *Install or Upgrade EMS/BMS*	0.2	0.01	$5	2.8
Domestic Hot Water: *Separate DHW from Heating*	0.2	0.01	$21	9.6
Heating System: *Upgrade Boiler*	0.2	0.01	$20	20.2
Heating System: *Replace Burner*	0.2	0.01	$9	5.8
Total	1.5	0.07	$106	
Top Segments, Top Measures				
Total of top 5 ECMs in top 3 segments	6.5	0.33	$441	
Percent of all segments potential savings	31%	32%	20%	

Table 9: Payback Summary

Payback (Years)	Avg. $/SF	Potential Source Energy Savings (TBTU)	Percent of Source Energy Savings	Retrofit Cost (Million $)	Percent of Total Cost	Average Payback (Years)
<3	$0.11	4.2	20%	$90	4%	2
3-5	$0.53	6.8	33%	$780	36%	4
5-10	$0.21	5.4	26%	$340	16%	5
>10	$0.73	4.5	22%	$970	44%	15
Total		20.9	100%	$2,180	100%	6

Figure 11: Estimated Energy Conservation Measure Payback



This chart shows the payback and source energy savings of the ECMs over time. The majority of the source energy savings comes from ECMs that have a payback of less than five years.

with paybacks of less than five years. Implementing these most-frequently recommended measures would cost only 40% of all estimated costs for implementing all measures. Though the types of ECMs were evenly distributed throughout the payback periods, the frequency of these recommendations varied. ECMs with a payback between 3-5 years were most frequently recommmended (56%), followed by ECMs with a 5-10 year payback (22%). ECMs with very short paybacks or very long paybacks comprised 10% and 12% of recommendations, respectively.

Opportunities by Location

After determining the building typologies with the greatest potential energy savings and their recommended ECMs, it is critical to understand where these opportunities exist within the city. Mapping carbon reduction potential will be an important tool for the City's Retrofit Accelerator and other energy efficiency programs in determining where to focus resources.

Map 3 shows the percentage of total potential source energy reduction for each community district, and which multifamily segment within each community district represents the greatest opportunity for source energy savings, based on the first year of Energy Audit Law data. Manhattan houses the greatest opportunity for source energy savings in NYC due to the high density of properties (see Map 1), and the large amount of Post-war properties that use Oil and Gas as the primary heating fuel. Consistently, the community districts with the highest building density have the greatest opportunity for source energy savings.

The segments with the most opportunity for energy savings are: Post-war Oil in Stuyvesant Town/Turtle Bay (CD 106), Pre-War Mid-rise Oil in the Upper West Side (CD 107), and Post-war Oil on the Upper East Side (CD 108). These three districts represent 22% of the potential energy savings from all covered multifamily buildings. The next tier of community districts, located mostly in Manhattan along with a few in the outer boroughs,

Clean Heat

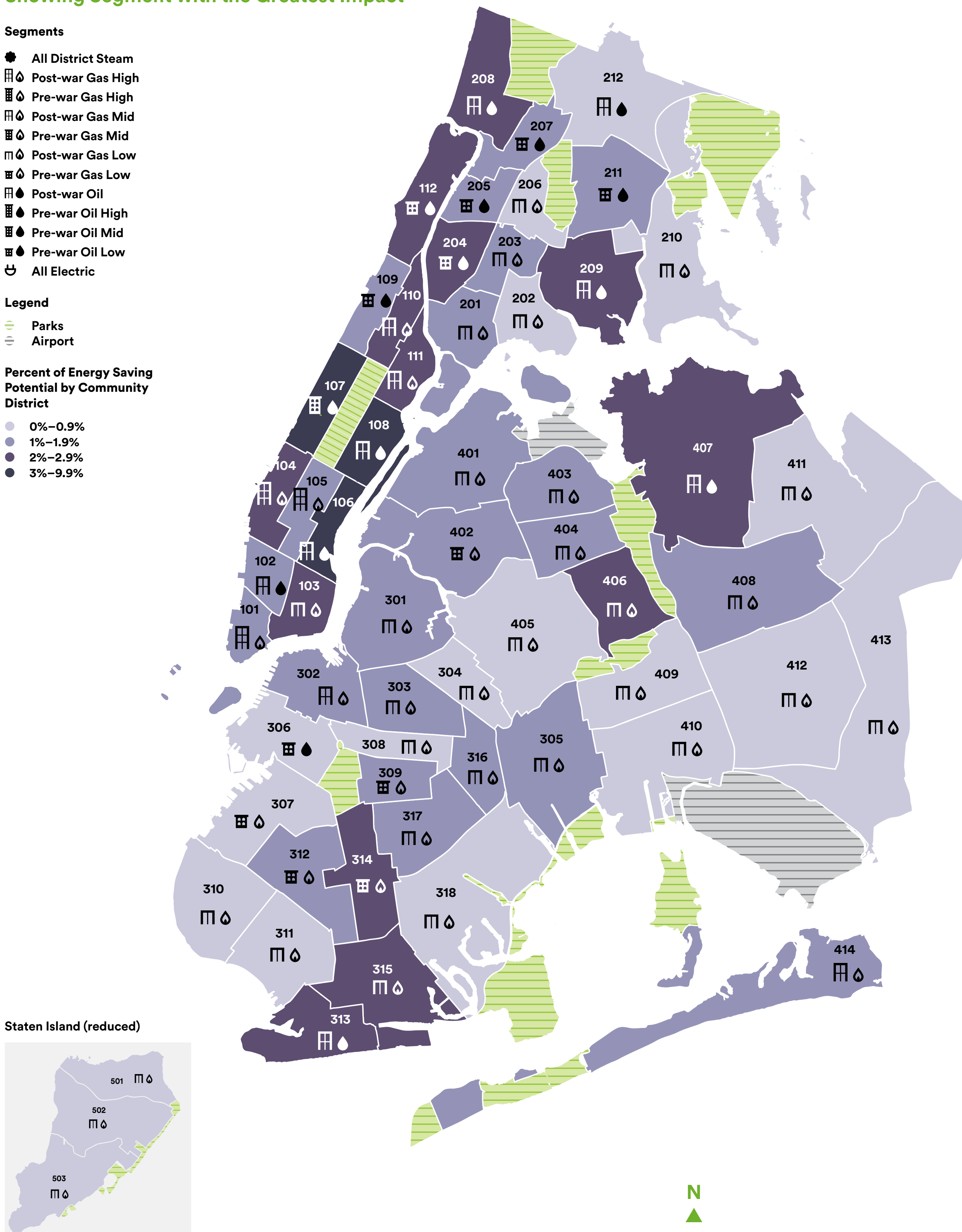
In 2012, the City enacted laws to phase out No. 6 oil by July 2015 and No. 4 Oil by 2030. To help buildings comply with the law, the City created the "NYC Clean Heat Program." This program helps accelerate fuel oil conversions to the cleanest fuels (bio-diesel, ultra-low sulfur No. 2 oil, and natural gas) with the goal of reducing emissions of particulate matter. To date, the City now has the cleanest air in 50 years, creating a healthier city for all.

Water Efficiency Opportunities

This report focuses on the energy efficiency improvement potential in New York City's multifamily buildings, though another huge opportunity to reduce waste and improve affordability lies in water usage in the City's buildings. While beyond the scope of this report, there is an urgent need to better understand how to target the massive savings potential from water savings measures.

Local Law 84 requires not just energy benchmarking, but also annual water benchmarking and disclosure. The analysis done by the City of New York of the water benchmarking data submitted shows a very wide range of water use among multifamily buildings, ranging from nearly zero, up to over 200 gallons of water per square foot. Further analysis of the water consumption data, and some auditing of water savings opportunities in multifamily buildings, should be a high priority for follow-on work.

Map 3: Distribution of Citywide Potential Source Energy Savings by Community District, Showing Segment with the Greatest Impact



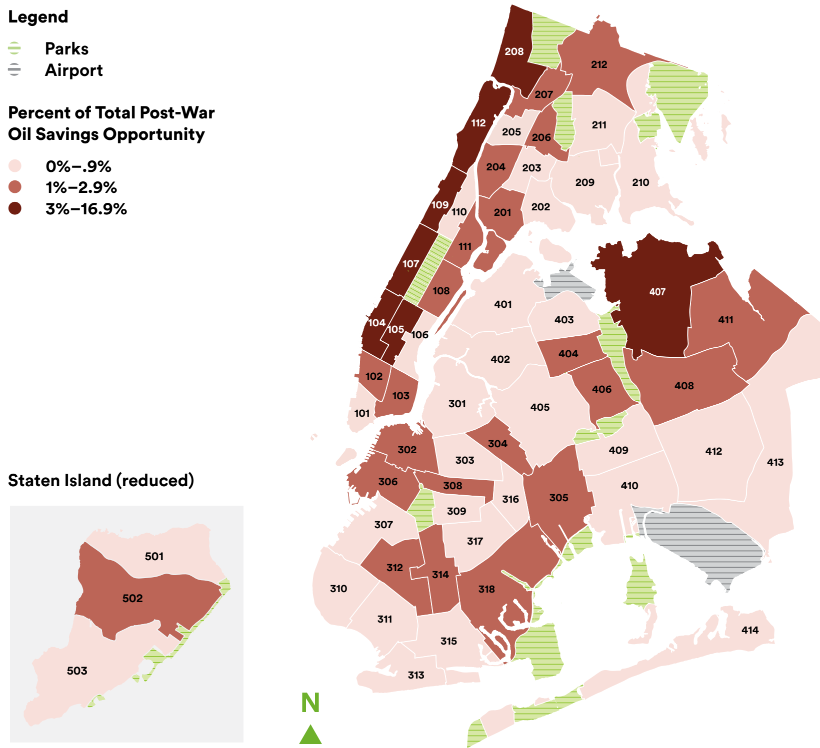
Map 3 shows the distribution of the potential energy savings that can be achieved if all ECMs were implemented. The darker community districts indicate areas of greater potential savings. The icon depicts the segment with the greatest opportunity for source energy savings.

represents 32% of the potential energy savings from all covered multifamily buildings.

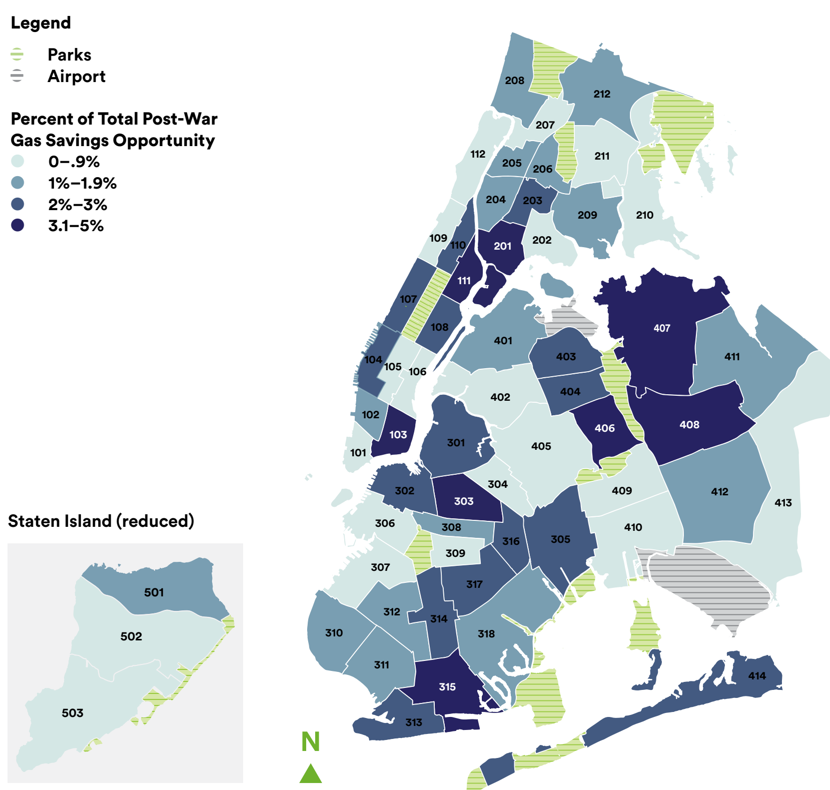
The Post-war Oil map illustrates the distribution of the savings from this segment (3.7 TBTU, or 18%) across multifamily properties in New York City (Table 4). The darkest areas have the greatest opportunity for saving energy and reducing emissions in the Post-war Oil segment. These areas, representing 54% of the potential energy savings for this segment are concentrated in the west side of Manhattan, northeastern Queens and the north Bronx. If targeting retrofits in this segment, the darkest areas show locations of greatest potential savings.

The combined potential energy savings from Post-war Gas Low-rise and Post-war Gas Mid-rise properties is 7.6 TBTU or 36% of all savings from all ECMs from all segments. The distribution of the savings from these segments is more evenly spread throughout the City (see Map 5). Though there is significant opportunity for source energy savings on the east side of Manhattan, much of the opportunity is distributed through Brooklyn and Queens as well. The darkest areas represent 29% of the potential energy savings in these segments. These maps, along with Map 2, may help inform energy efficiency programs where to target marketing campaigns based on the building segments and the potential for energy savings in each community district.

Map 4: Distribution of Post-war Oil Savings



Map 5: Distribution of Post-war Gas Savings



Map 4 and Map 5 show the distribution of potential source energy savings if all ECMs were implemented in the Post-war Oil segment and Post-war Gas (Low-rise and Mid-rise) segments respectively. The darker community districts indicate areas of greater potential savings.

Broad support for New York City's climate action plan will require good faith efforts to ensure that the benefits are distributed among all communities. Although implementing energy efficiency projects in affordable housing represents a special set of challenges, occupants of these buildings spend a far greater percentage of their income on energy costs and will realize commensurately greater benefits if these costs are reduced.

Although resolving the various barriers to implementing energy retrofits in affordable housing is beyond the purview of this report, understanding the disposition and location of affordable buildings, and the selection of retrofit measures most commonly recommended by auditors, are strong first steps in addressing this important portion of the multifamily building sector.

Affordable properties, defined here as those in the SHIP dataset and in HPD, HDC, and NYCHA portfolios, comprise approximately 31% of the floor area, and 37% of the energy use of all covered multifamily properties. More than 75% of these affordable properties are Post-war buildings.

Linking Segments to Affordable Housing Types

To identify areas where there is both a high proportion of affordable housing and a high proportion of buildings with significant energy savings potential, available affordability data has been married with the technical analysis of the multifamily segments described earlier.

Affordable housing can be found in almost every community district across New York City, but the highest concentrations are found in areas that also have a low median household income (see Maps 6 and 7). These areas also experience gross rent burden, meaning the average resident in these areas spends over 30% of their income on the combination of rent and utilities (see Map 8). With the available data it is difficult to determine exactly what proportion of these household's incomes are spent on utilities, but it is likely that many of these communities experience an "energy affordability burden." Further work investigating the different energy subsidy programs available to low-income consumers, and a more specific understanding of their true energy costs would be useful to understand the impacts of energy cost burdens on top of high rent burdens. This would help identify which lower income New Yorkers are at risk for, or are living in, "energy poverty," spending a significant share of disposable income on their utility bills.

Table 10: Percent Difference in Affordable Covered Multifamily Source Energy Use by Segment

Segment	Affordable Area (Million SF)	Percent of Segment Area Affordable	Affordable EUI	Non-Affordable EUI	Percent Difference*	Savings Potential within Segment	Payback (years)
Post-war Gas Low	115	43%	179	125	30%	16%	5.4
Pre-war Gas Low	35	22%	168	117	30%	13%	4.8
Pre-war Oil Low	11	10%	163	126	23%	13%	4.1
Pre-war Gas Mid	5	8%	170	133	21%	5%	10.4
Post-war Gas Mid	117	54%	164	135	18%	10%	7.7
All Electric	16	21%	116	96	17%	16%	6.8
Post-war Gas High	108	48%	171	153	11%	5%	4.2
District Steam	13	13%	160	144	10%	5%	4.8
Post-war Oil	61	30%	142	135	5%	14%	5.0
Pre-war Oil Mid	2	1%	118	115	3%	14%	4.6
Pre-war Gas High	3	23%	159	161	-2%	--	
Pre-war Oil High	2	14%	116	132	-14%	--	
Total	486	31%	165	129	22%	11%	5.9

*This percent difference is a simple comparison of the means of affordable properties (defined here as in the NYCHA, HDC, HPD, and SHIP databases) and non-affordable covered multifamily properties.

In order to better understand where the best opportunities for energy efficiency retrofits can be found among covered multifamily affordable housing, this study looked at multiple factors:

1. The concentration of covered multifamily affordable housing in each community district
2. The potential energy savings from covered multifamily affordable housing in each district
3. The segment in each community district with the greatest potential energy savings within covered multifamily affordable housing
4. The total potential savings and exxpected payback from all recommended energy conservation measures for the segment identified in step 3

Together these steps identify areas with affordable housing that would most benefit from energy efficiency retrofits, which single segment offers the greatest opportunity for energy savings in a community district, and the estimated payback of implementing a retrofit.

Observations

Focusing on the highest potential multifamily segments within each community district could assist in the development of a "package" of energy conservation measures that best suit that specific affordable housing stock, reducing complexity and helping scale the market for retrofits.

Map 6, Concentration of Affordable Properties, shows the segment with the highest opportunity for energy savings within the affordable properties in each community district as well as the concentration of covered affordable housing in each community district.

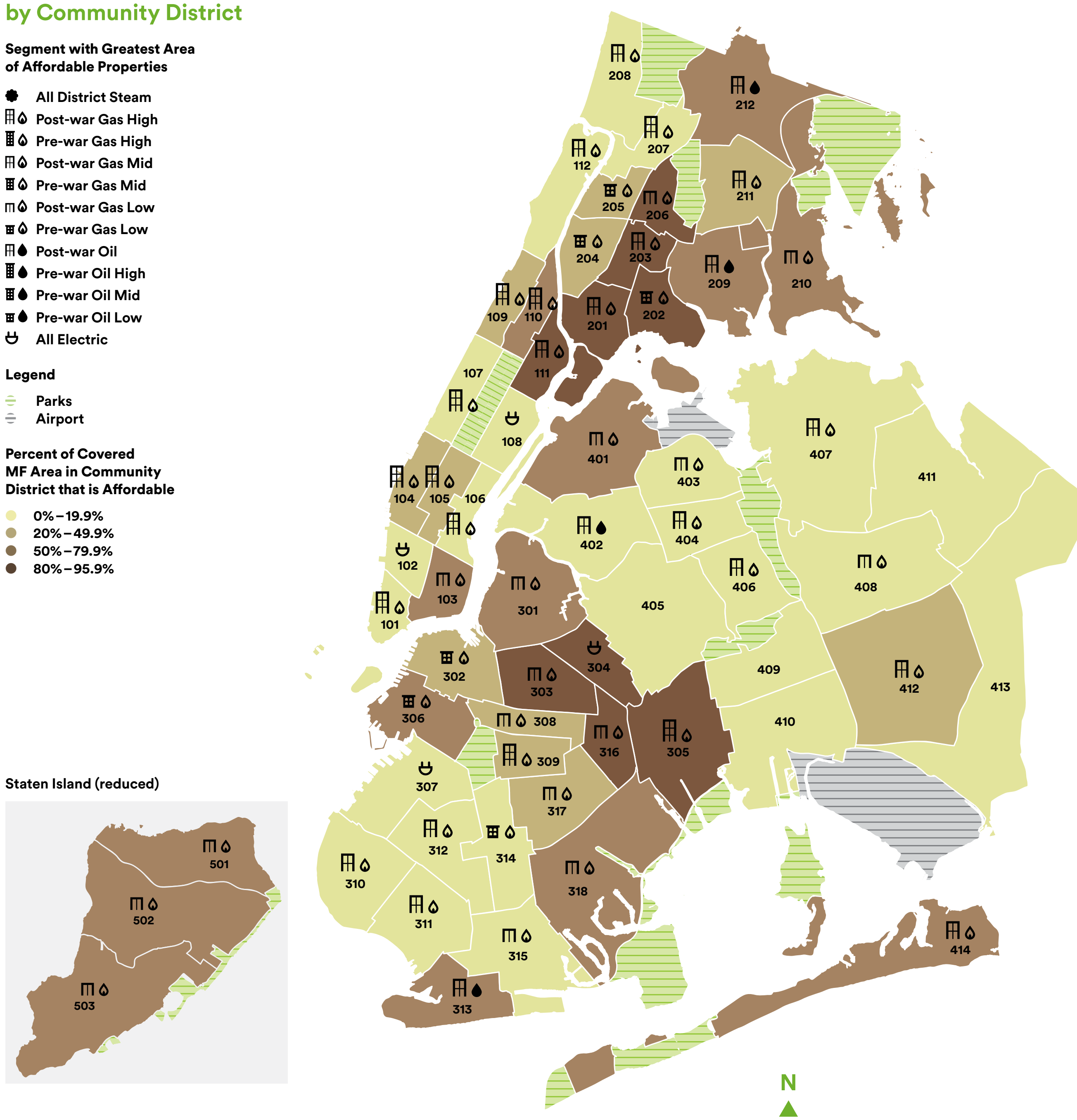
Cross-referencing high concentrations of affordable buildings with the segments that represent the greatest source energy savings potential provides high level guidance on where to focus energy efficiency programs in each community. It is notable that segments such as Pre- and Post-war Gas Low-rise, and All Electric, have double the potential

Affordable Properties Data Challenges

There are several diverse datasets containing information on New York City's affordable properties. This report blends the most comprehensive datasets, SHIP, HPD, HDC, and NYCHA, to determine affordable properties covered by the Benchmarking law. However, the reported affordable data can contain many omissions and inconsistencies. A high percentage of affordable properties did make it through the data cleaning process; however, the majority of NYCHA properties were removed in the original cleaning process (June 2015 edition). In this edition, the authors have worked with NYCHA's energy and data team in order to improve their data reporting and adjust the data cleaning process used in this analysis. This expanded the overall number of affordable properties for this report, from 1,185 to 1,408.

Because affordable properties are under-represented in the new Energy Audit Data (LL87), determining ECMs specific to affordable properties was not possible. As the available data increases with annual collection, there may be an opportunity to analyze potential ECM variations between affordable and non-affordable buildings.

Map 6: Concentration of Affordable Covered Multifamily Properties by Community District



This map shows the concentration of covered affordable multifamily properties by community district. The darker color indicates a higher concentration of affordable properties. Each community district also displays the icon of the segment with the greatest potential source energy savings within the covered multifamily buildings.

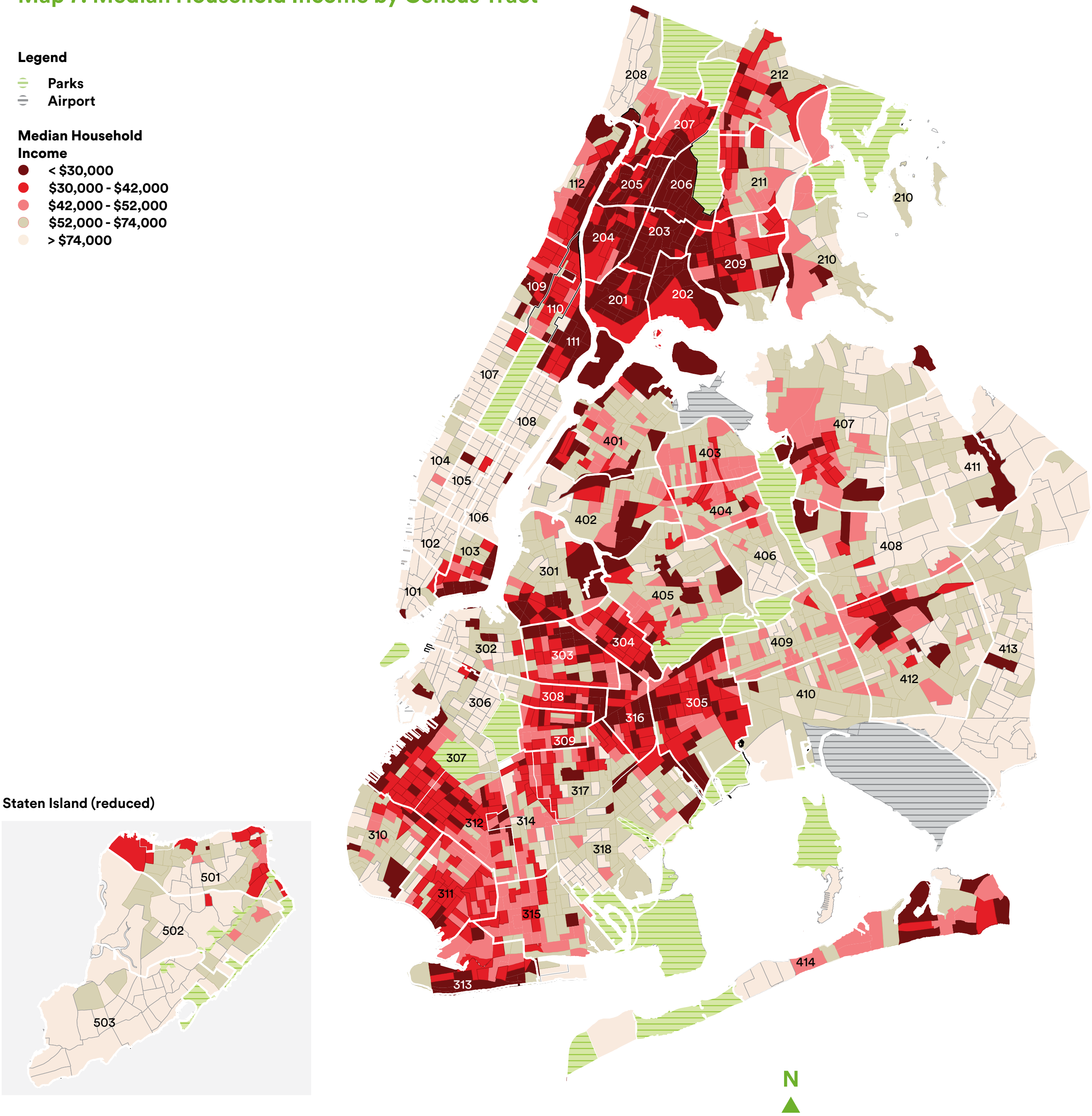
depth of savings compared to other segments (see Table 10).

In general, the greatest opportunity for source energy savings in affordable covered multifamily buildings are found in the South Bronx, and central Brooklyn, where the majority of buildings are Low-rise and use gas as their primary heating fuel.

In areas where the concentration of affordable multifamily area exceeds 80%, the savings from affordable homes represent at least 40% of the potential energy savings for the entire community district.

More specifically, neighborhoods in the South Bronx represent the greatest

Map 7: Median Household Income by Census Tract



This map shows the median household by census tract across the city. Darker areas indicate communities that have a lower income. These areas track closely with areas of high concentrations of affordable housing, as seen in Map 6.

opportunity, including Motthave/ Melrose (CD 201), Hunstpoint/ Longwood (CD 202), Morrisania/ Crotona (CD 203), and Belmont/ East Tremont (CD 206). These areas have a high concentration of affordable housing, and the majority of the affordable properties are Post-War Gas Low- or Mid-rise. Implementing energy efficiency retrofits in these areas would not only have a high depth of energy savings in the community district, it also comprises nearly 15.6% of all savings from covered affordable multifamily properties in the city.

Areas in central Brooklyn are also ripe for savings, including Bedford-Stuyvesant

Map 8: Gross Rent Burden by Census Tract

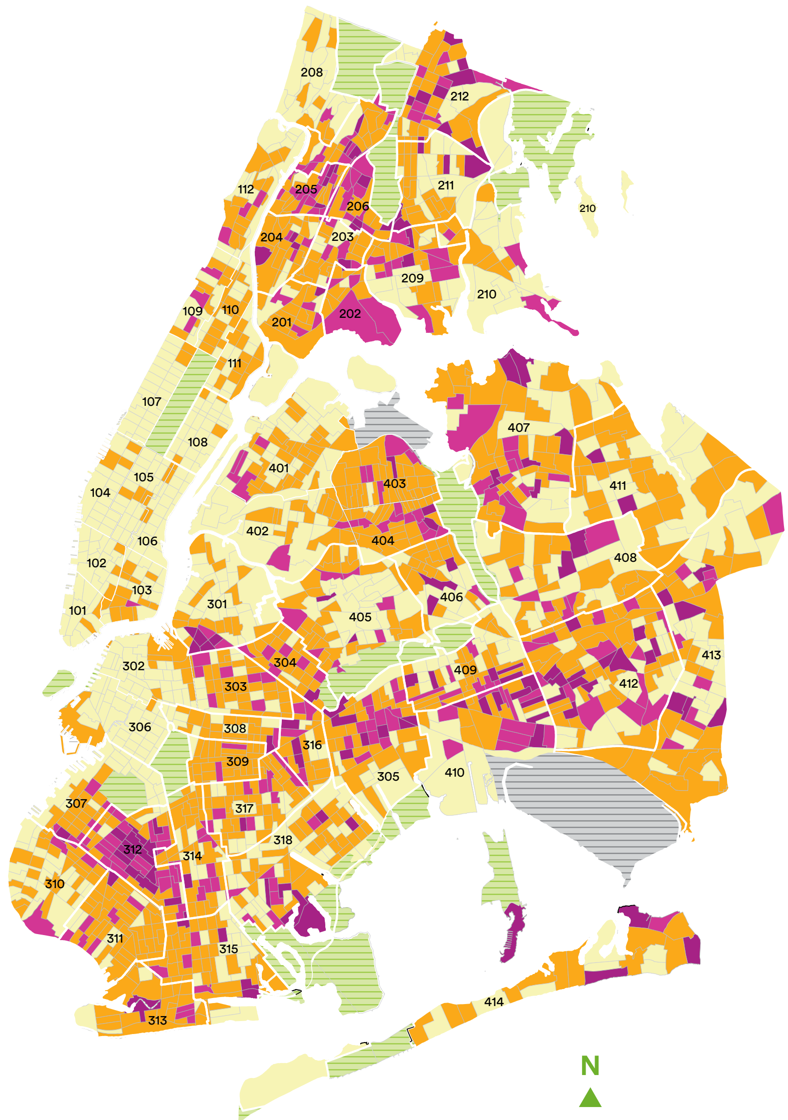
All District Steam
Post-war Gas High
Pre-War Gas High
Post-war Gas Mid
Pre-war Gas Mid
Post-war Gas Low
Pre-war Gas Low
Post-war Oil
Pre-War Oil High
Pre-war Oil Mid
Pre-war Oil Low
All Electric

Legend

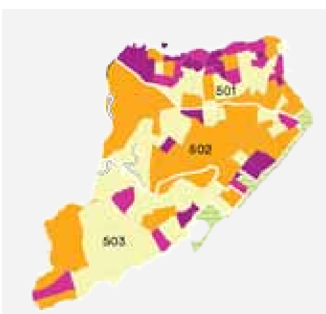
Parks
Airport

2013 Gross Rent Burden

- < 30% Not rent burdened
- 30.1–40% Rent burdened
- 40.1–50% Rent burdened
- >50% Severely rent burdened



Staten Island (reduced)



This map shows the gross rent burden by census tract. Again, the areas of high gross rent burden are also the areas with greatest concentration of affordable housing as seen in Map 6, and areas of low Median Household Income as seen in Map 7.

(CD 303), Bushwick (CD 304), East New York (CD 305), and Brownsville (CD 316), which are included in Con Edison's Demand Management Program.[25] The Post-War Low-rise Gas buildings in Bedford-Stuyvesant have the greatest energy reduction potential (16%) and a relatively low cost per energy saved (see Table 5). The Lower East Side (CD 103), East Harlem (CD 111), and the Rockaways (CD 414) also represeant large energy reduction potential. These three areas combined represent 16% of all potential savings in affordable covered multifamily properties.

Although this report only skims the surface of energy efficiency retrofit opportunities within affordable buildings in NYC, analyzing the disposition and location of buildings of greatest potential is a strong indicator for future efforts. However, more research is needed to better understand this sector and ensure that affordability buildings are party to the lower utility bills and improved environmental quality that result from energy conservation measures.

challenges

Many of the multifamily stakeholders who must approve and implement efficiency retrofits find energy to be "amorphous and difficult to measure." This uncertainty compounds an already challenging environment in which energy efficiency must compete for the attention and resources of key decision-makers. The difficulty of simply maintaining, leasing, financing, and operating a building in New York City often makes energy efficiency a low priority, and in many cases it is not considered at all.

Furthermore, the constantly evolving landscape of multiple incentive programs offered by myriad entities significantly increases confusion. Barriers within the multifamily sector vary dramatically across different building typologies and different ownership structures. There are few one-size-fits-all solutions. Condo, co-op, market rate, rent controlled, and subsidized buildings all represent unique challenges to the pursuit of energy efficiency retrofits.

Efficiency is a Low Priority

Property owners and operators have many priorities and are most often focused on improvements that require immediate attention, with little time for issues as abstract as energy efficiency.

When the boiler breaks, the elevator stops, or an apartment needs to be re-leased, including energy efficiency in the project parameters often is simply not on the building manager's list of concerns. They are often unaware of energy efficiency opportunities and their benefits. For some buildings, low fuel costs can reduce the perceived benefits for many retrofits. Additionally, in many buildings the savings and benefits of the retrofit may not accrue directly to the person who must initiate and pay for the project. At the time when a building owner may choose to pursue an energy efficiency retrofit, he or she is often daunted by the confusing process and usually high upfront costs.

Many energy efficiency opportunities are related to other events, for instance, the need to replace equipment, and certain ownership structures do not lend themselves to acting quickly at these moments. Co-op boards and condo homeowner associations are typically risk averse and deliberative. Many other building owners are located outside the city and may be inaccessible when a capital project presents itself. Still other building owners are financially constrained, with no or little access to capital for a retrofit project. Due to these and other factors, energy efficiency often remains a low priority for key decision makers in this sector.

Investor Confidence Project

The Investor Confidence Project (ICP) developed by the Environmental Defense Fund (EDF) provides a roadmap for energy efficiency retrofits in multifamily and commercial buildings. It aims for all projects to be cost-effective and provide stable, predictable, and reliable savings. The ICP outlines project development specifications to insure that projects are "Investor Ready Energy Efficiency" and certifies project developers and software providers to ensure the proper measurement of savings. Through these practices, the ICP reduces transaction costs by assembling existing standards and practices into a consistent and transparent process promoting efficient markets by increasing confidence in energy efficiency as a demand-side resource. Incorporating these or similar standards into the design of the City's Retrofit Accelerator can establish a foundation of documented savings from consistently performed energy efficiency retrofits and can help alleviate uncertainty for future projects.

To learn more about the Investor Confidence Project, please visit: www.http://be-exchange.org/resources/source/60

Outcome Uncertainty

Most energy efficiency retrofits have not been documented sufficiently to quantify the true savings and benefits. This lack of post-project documentation, as well as the perceived uniqueness of individual buildings, leads to significant uncertainty about the benefits of energy conservation measures.

Any uncertainty about the outcomes of various ECMs, both in terms of actual savings and actual costs, makes decision-makers uncomfortable about investing in upgrades. In the emergent market of energy efficiency, there are many questions: how much will the project really cost; how much will it actually lower the utility bill; will it work as advertised; will it attract or repel tenants; what are the maintenance, operations and commissioning considerations; as well as other concerns. This pervasive uncertainty about outcomes often leads to a lack of trust in the providers, which creates a cycle: people don't invest because there are not enough projects with good data available, and because people are not investing, data collection and results from new projects cannot achieve scale.

Several different studies have attempted to better quantify the actual energy savings from implemented energy efficiency projects in multifamily buildings, and to compare this actual savings to the savings projections.[26] Though these studies generally found program-wide savings between 10–25%, the datasets usually have a relatively small sample size (50–250 buildings) and a wide variety of scopes and methodologies. It is important to continue to communicate actual savings and realization rates to combat the perceived uncertainty about outcomes.

Financial Constraints

Restricted access to capital can be a significant barrier for multifamily building owners and property managers that wish to pursue energy conservation retrofits.

Any discussion of energy cost savings or potential payback assumes an ability to spend capital on an energy efficiency retrofit. Without access to capital, these savings, no matter how large, cannot be realized. Financial limitations exist for both the market-rate and affordable sectors of multifamily housing, and there is a lack of knowledge regarding available green financing resources. Furthermore, the operations savings and capital improvement value of effective retrofits is not well understood nor widely accepted as a means to help underwrite the project costs. In the affordable sector, each type of housing (NYCHA, Section 8, Mitchell Lama, HUD-financed, LIHTC, HPD, etc.) have different legal and financing structures, often requiring separate solutions.

Timing can also be a critical factor in financing a project. For capital constrained owners, re-financing may be one of the few times they can consider a retrofit. This narrow window can easily be missed if energy reduction and efficiency are not a priority, or at least part of the discussion. It is important that financing for energy efficiency not be limited to only energy-specific financing programs. The overall real estate lending community should become educated in the benefits of energy efficiency and conventional lenders and mortgage programs recognize and encourage energy efficiency as part of their everyday business.

path forward

Bringing energy efficiency to the entire multifamily housing sector will require education, assistance, and persistence. Energy efficiency retrofits must be easily understood and consistently successful in order to be considered a sound investment. The Building Energy Exchange proposes a staged, targeted approach to scaling-up energy efficiency retrofits in multifamily buildings, including near term actions that can harness current initiatives and longer-term strategies to sustain the growth of efficiency within this critical sector.

We believe a successful path forward for scaling multifamily energy efficiency should focus on the following:

- **Fuel Switching:** Continue programs to shift buildings away from the heaviest heating fuels
- **Direct Outreach:** Launch the Retrofit Accelerator program proposed in *One City: Built to Last* to assist property owners in pursuit of retrofit projects
- **Demonstration Projects:** Incentivize, track, document and publicize successful energy efficiency retrofits within multiple segments
- **Training & Education:** Increase outreach to all stakeholders, and targeted technical training where required
- **Data Management:** Develop a framework, and identify a host, for energy and retrofit data so that it may be easily aggregated, shared and analyzed
- **Market Research:** Conduct additional research to identify the most important market actors, including programs to reduce tenant use
- **Technical Research:** Study the long term benefits of staged deep retrofit plans, rather than measure by measure efforts, and compare to climate action goals
- **Service Firm Support:** Develop programs that will ensure a viable and profitable market for energy service firms

There is no single program or policy that can produce widespread adoption of energy efficiency retrofits in the highly fragmented multifamily building market. These proposed measures will significantly demystify energy efficiency and put this critical building sector on a pathway to deep carbon reductions, reducing the energy burden of tenants across the city and contributing massively to a cleaner, healthier environment.

Set the Stage - Now

New York City and State energy policies are in transition. To reach the bold goals currently outlined for the building sector, a clear understanding of the current actors and energy end-uses, and how these are likely to be impacted by near term changes to energy regulatory structures are important components to ensure resources are focused effectively.

Market Research

Through the implementation of the Greener, Greater Buildings Plan, and additional initiatives such as PlaNYC and the Clean Heat program, both private and public building owners and managers are becoming more

Transitioning to 80 × 50

In the *One City, Built to Last* climate action plan, Mayor de Blasio committed New York City to an ambitious target of reducing carbon emissions 80% by 2050, as compared to a 2005 baseline. Achieving that target will require technologies and practices that are not yet widely used, and will force a major shift away from burning fuels in buildings to using electricity for all end uses (including heating and water heating) with the presumption that the electric supply serving NYC will be nearly carbon free by that time. Some of the technologies that will be needed to reach the 80 by 50 target cannot feasibly be implemented in the near term, and some measures that can be implemented may require replacement prior to 2050 to meet our long term goals. Many of the measures recommended by today's energy audits, while more efficient than current practice, continue our reliance on fuel combustion in buildings.

Despite this, implementing current audit recommendations is a critical foundation for meeting the 80 by 50 goal in several key respects. Accelerating such work will establish clear market pathways for energy retrofits that will greatly benefit the deeper retrofits of the future, socializing many stakeholders to the retrofit process and unlocking monies that might otherwise have been spent on energy. This foundational work will also provide breathing room for further development of technology and infrastructure and represent a significant step toward the interim goal of 30% by 2025.

Energy Audit Quality

Though the Energy Audit Law requiring energy audits in all large buildings is a new mandate, some energy professionals have been auditing NYC buildings for leading owners and managers since the energy crisis of the 1970s. Concerns have been raised about the quality of some audits prepared and submitted since the Energy Audit Law took effect in 2013. Not surprisingly, many audits meet only minimum requirements and owners are choosing their auditors based on the lowest cost. Both of these factors may result in lower quality audits.

It will be important going forward to closely monitor the quality of audits, and remove auditors found to be doing lower quality work. It will also be useful for NYC to stay involved with audit standardization work being done through ASHRAE and others, while recognizing that energy auditing is as much an art as a science.

familiar with energy efficiency requirements and the need to reduce carbon emissions. Currently, the City can draw a clear picture of the energy use of its covered buildings using the data from existing benchmarking and emerging energy audit data sets. However, the majority of multifamily properties have several decision makers, making the path to implementing energy efficiency retrofits more convoluted. The City is taking the first step to identify key decision makers and motivators in this space by launching a large market research study alongside the “Retrofit Accelerator”. With a clear insight into the market, the City can design effective programs that will improve energy efficiency, reduce carbon emissions, and reach milestones along the route to the 80 by 50 goal.

Fuel Switching – Clean Heat

Continuing Clean Heat, the City’s successful fuel-switching program, is important to capturing current carbon reduction opportunities while reducing harmful particulates from the dirtiest fuels. These particulates have the greatest impact on the City’s densest communities, as well as some of the least advantaged communities. Moving multifamily buildings currently burning #4 and #6 oil to transition fuels, such as natural gas and #2 oil, have immediate, tangible benefits, including improved health, lower carbon emissions, and lower operating costs. In addition, the fuel conversion project represents an important opening to engage customers in a discussion of other energy efficiency opportunities.

Comparative Annual Data Analysis

A program of year over year analysis will uncover buildings that can benefit most from energy efficiency retrofits, and will assist in the evaluation of retro-commissioning measures and retrofits that were previously performed. Buildings should be tracked over time, using the data from the Benchmarking Law, with a clear indicator in the year that an Energy Audit Law report was filed and/or a retrofit occurred. This will enable the City to uncover changes in energy performance that may indicate opportunities for improvement, as well as to assess whether retrofits have been successful.

Furthermore, comparing the Energy Audit Law data between years, even though the datasets cover different buildings, will give a sense of the evolving nature and quality of the work being done under this mandate. Since this is the first year of this audit data, there were many inconsistencies in the dataset. It will be interesting to see how audits improve or change over the years and whether the most common ECMs fluctuate.

Data Collection

To make the most effective policy decisions and provide the best information to building decision-makers, there is a critical need for better data collection and management. While New York City has demonstrated significant leadership in the drive to understand energy usage in the built environment, there is a need for ongoing evaluation and improvements to what benchmarking and audit data is collected and in particular, how it is created. An iterative assessment is needed, including screening the collection methods, educating the auditors, ensuring consistency and simplicity of input, and providing an accessible and transparent portal to evaluate the collected data.

In order to best utilize the data collected from the Energy Audit Law and to a lesser extent the Benchmarking Law, the authors recommend that the City revise its data management system.

On the data input side, simple changes like using a database application with drop-down boxes that include specific options instead of an open text box would simplify the work of both auditors and analysts. Before submitting audits, it would be best if there were a program similar to the EPA Portfolio Manager that automatically checks for errors, so that auditors could know which information to revise. Additionally, data should be managed in a database equipped to handle huge datasets. This will allow for cleaner and easier data analysis, especially when comparing year over year data. With such information, the City can make better-informed policies and market confidence will improve significantly.

Currently, there is an initiative to expand the Benchmarking Law and Energy Audit Law to incorporate mid-size properties, between 25,000 and 50,000 square feet. This would include an additional 400 million square feet citywide, about half of which would be multifamily buildings. Though this is only a 15% increase in multifamily area, this encompasses many properties, meaning more New Yorkers could benefit from lower utility costs and quality of life improvements.

Build the Potential – 2016-2018

The Retrofit Accelerator will bring data-driven, guided retrofits to multifamily buildings across the city.

Using collected data and targeted market research, the City will implement a sales force approach to assist buildings that can most benefit from low-cost, high-impact retrofits. The Retrofit Accelerator account managers will identify buildings with the greatest energy saving potential and assist building owners and other decision-makers to implement water and energy efficiency retrofit projects. Once a decision-maker is engaged, the account manager will help identify appropriate technologies, resources (many of which will be available at the Building Energy Exchange, BEEx), and financing opportunities (such as those offered by the New York City Energy Efficiency Corporation). Throughout this process, BEEx will function as an education and information hub for the Accelerator, where building owners and property managers can visit informative exhibits about multifamily retrofits, meet with project partners and vendors in a neutral space and connect with energy efficiency trainings, case studies, research and other resources. In addition, the City will continue to stimulate workforce development, focusing on job skills training and placement for New Yorkers from underserved areas. This coordinated assistance is designed to increase the adoption of energy efficiency retrofits, and reduce friction for projects that are undertaken.

The analysis from *Retrofitting Affordability* will provide a road map for the Accelerator, informing the program as to which types of properties might be targeted, and in which communities, to produce the greatest carbon emissions reductions and most effectively preserve the affordability of housing. The analytical framework and methodology of *Retrofitting Affordability* is fully replicable, and can quickly incorporate and analyze Energy Audit Law data from future years to further refine the results presented here.

NYSERDA Multifamily Performance Program (MPP)

The NYSERDA Multifamily Performance Program assists multifamily properties of more than 5 units to reduce their energy usae by at least 15% by providing funding for: energy audits, energy reduction plan development, and energy conservation measures implementation. Buildings that participate in the MPP are matched with NYSERDA-approved partners who are experienced energy efficiency experts, who carefully monitor energy use both before and after retrofits. Participants in MPP are encouraged to look at whole-building solutions, and can reach energy savings up to 22%. This incentive-based program continues to help mobilize the market by encouraging building owners to invest in energy efficiency retrofits and meeting this demand with qualified energy services providers.

National Grid Energy Efficiency Programs

National Grid, an international electricity and gas utility provides natural gas service throughout New York City and State. National Grid's energy efficiency programs provide incentives for multifamily buildings of 5 to up to 75 units, depending on the service area. In addition, to a sizable portfolio of prescriptive and custom natural gas efficiency incentive offerings, National Grid's Direct Install Program offers Multifamily Building owners no-cost installation of high efficiency water and energy saving measures. Leveraging these programs National Grid will help customers undertake energy efficiency upgrades and convert to cleaner fuels such as natural gas in support of NYC Energy Retrofit Accelerator program.

The NYCEEC efficienSEE™ Calculator: An Energy Savings Calculator for Large New York City Multifamily Buildings

The New York City Energy Efficiency Corporation (NYCEEC) efficienSEE™ Calculator provides quick, building-specific savings projections associated with typical cost effective energy efficiency measures. Each savings projection is customized based on key building attributes and is shown in terms of dollars saved, energy reduced, and greenhouse gas eliminated. The tool breaks out savings between fuel and electric measures and can also generate cost savings for cogeneration. Currently, efficienSEE™ can be used for large multifamily buildings over 50,000 square feet in New York City.

Primarily targeting building owners and property managers, the NYCEEC efficienSEE™ Calculator uses owner-generated reports submitted under the Benchmarking Law. Each building is grouped with comparable New York City buildings based on age, height and affordability status — factors that the data demonstrates are statistically relevant when determining the optimal energy use profile of a given building. Based on historical savings data provided by NYSERDA, a building's projected energy savings is then calculated relative to its peers. efficienSEE™ was developed by NYCEEC, in partnership with the Steven Winter Associates and with assistance from WegoWise and Michael Blasnik Associates.

To learn more and to try the NYCEEC efficienSEE™ Calculator, visit: www.nyceec.com/efficienSEE

Show the Way – 2017-2019

There is a clear need for well-documented projects that provide a "proof of concept" for energy efficient retrofits in the multifamily sector. Besides simplifying the process to initiate an energy efficiency retrofit, energy service providers must also demonstrate that the measures they recommend are effective and clearly document the actual return on investment of various energy conservation measures.

Currently, much of the information and performance claims of retrofits come from providers of energy services and technology, and predicted results are often met with skepticism by building owners and operators. To demonstrate and quantify actual savings, strategic pilot projects must be implemented, monitored, verified, and documented. The information from these projects will become case studies and marketing opportunities. Demonstration projects should be curated that will quantify the actual energy savings of the ECMs, as well as the actual project costs in relation to energy bill savings, for the different multifamily building segments.

Results from a carefully selected set of demonstration projects can also be used in an analysis of what could be considered a "reasonable" payback, or return on investment (ROI), recognizing that the constraints of affordable and market rate housing are very different. The policy priorities and types of market stimulation required for ECMs that pay for themselves through reduced energy costs in less than five years, for instance, may be very different than ECMs with an ROI of 10 or 15 years; or if the building is market rate, subsidized, or rent controlled. Which ECMs and building types need assistance to scale, versus those retrofits that can be reasonably expected or mandated, needs to be clearly understood and should be informed by these pilot projects.

Three to four demonstration projects in each of the multifamily building segments should be initiated that can validate energy conservation measure costs, effectiveness, savings, non-energy benefits, and return on investment. To better inform both owners and policy makers, it is especially important to clearly document all ECMs that have a payback of less than 25 years. Prime candidates to participate in demonstration pilot projects are the New York City Carbon Challenge Multifamily Program participants. Additionally, to target and improve affordable housing, a NYCHA performance contract demonstration project would lead the way for innovative retrofits in affordable housing.

The outcomes of these proof-of-concept projects, coupled with additional data analysis and market research, will lay the groundwork for informing policy, code revisions, programs and targeted incentives to effectively bring efficiency projects to scale, reducing carbon emissions, and maintaining affordable housing in NYC.

The Standardized Measure Study, an initiative by the Pratt Center, involving Bright Power, focuses on energy efficiency retrofits for smaller buildings . Because buildings with similar characteristics often benefit from the same ECMs, property owners do not have to undertake expensive audits to determine the best retrofit strategy for each individual building. To this end, Bright Power and the Pratt Center are developing a standard package for two-family, gas-heated brick homes.[27] This building type is prevalent in low- and moderate-income neighborhoods across NYC. This package, in conjunction with financing measures and community-based marketing, can help spur retrofits in this sector.

Analysis for this report, combined with improved year over year data from the Energy Audit law, could be used to create future ECM "packages" for covered multifamily buildings.

Make the Business Case – 2020-2030

Educated customers and highly skilled technical providers are required to develop a profitable energy efficiency retrofit market in New York City.

Achieving the long-term carbon reduction goals for NYC's multifamily buildings will require a robust and active market for energy services. With this in mind, implementing the ECMs identified in the audit data would not only provide pure energy and cost savings, it would also help prime a working market for energy efficiency services and technology. Demand for retrofit specific services and technology does not induce a fully formed market overnight. The ECMs identified in the audits, if pursued aggressively, would socialize the processes and resources required to implement successful retrofits within this complicated sector.

Public policy makers would be well advised to provide a clear framework and timeframe for incorporating ECMs, coupled with an understanding of where and when assistance may be required to meet any interim climate action goals. Structuring these goals by building segments may provide direction to both property owners and energy service providers and stimulate the market for energy services.

Existing programs such as the NYSERDA Multifamily Performance Program (see sidebar) and the Greener, Greater Buildings Plan laws have stimulated the energy efficiency retrofit market, and the Retrofit Accelerator program has the potential to build on these solid achievements. Policy makers must also support the business case for increasing the quantity and quality of retrofits by providing incentives that spur innovative and entrepreneurial business models, including relationships in which service providers contract with buildings to ensure performance over years, rather than doing one-off jobs.

Policy makers should also track the rate at which building owners are acting on their audit recommendations. If implementation of retrofits continues to lag, this may indicate improvements in the quality of audits themselves are necessary, or that mandates related to the implementation of ECMs with quick paybacks are needed. Tracking the Energy Audit Law data, and comparing it to the Benchmarking Law data each year will verify which measures are the most effective and provide guidance that will help dramatically scale the market for energy efficiency retrofits.

The lessons derived from this process should be communicated annually in various formats to all the stakeholders in the multifamily building sector to ensure the benefits of energy efficiency retrofits are understood and undertaken by all those involved.

Energy Efficiency for All

Energy Efficiency for All is a partnership between the Energy Foundation, Elevate Energy, the National Housing Trust and the Natural Resources Defense Council that was created to connect the energy and housing sectors together. The goal of this project is to accelerate energy efficiency retrofits in affordable multifamily buildings to benefit millions of low-income families.

Despite the wide range of potential benefits from multiple stakeholder perspectives, energy efficiency improvements are much less prevalent in multifamily rentals—especially affordable ones—than any other type of housing. The Energy Efficiency for All partnership recognizes this disparity and seeks to solve it by delivering tools and resources for utilities, regulators, housing finance agencies and building owners to implement best practices for energy savings in multifamily properties and foster growth in energy efficiency investments.

To learn more, visit: http://be-exchange.org/resources/source/59

Center for Market Innovation Multifamily Demonstration Pilot

The Natural Resources Defense Council (NRDC), through its Center for Market Innovation (CMI), is leading an exciting, affordable multifamily housing retrofit demonstration project. This project will showcase the process of making energy efficiency and renewable energy investments in affordable multifamily housing properties.

The objectives of this Project are: to engage with stakeholders in order to identify and address the real and perceived barriers impeding the adoption of triple bottom line investments,; to identify packages of energy performance measures that maximize energy cost savings, return on investment, and payback; and to explore financing options that can ease steep initial costs.

In order to accomplish these objectives, the Project will: document the process of assessing and implementing cost saving energy solutions; develop a value analysis tool that enables efficient assessment of high performance retrofit scenarios; and publish case studies that highlight financing strategies. These resources for building owners and developers are intended to accelerate the adoption of high performance energy and air quality measures in affordable multifamily buildings.

Multifamily buildings must play a central role in any plan to combat the climate crisis.

Multifamily buildings are home to most of our residents and represent the majority of New York City's built area. This study provides an overview of the potential for carbon reduction in multifamily buildings indicated by newly available data, and guidance for policy and program discussions among relevant stakeholders.

The findings illuminate both great potential and cause for concern, and identify a number of very effective measures that are simple to implement, will demonstrably improve the quality of living spaces, and pay for themselves quickly. Both private and public stakeholders should work to implement these measures as soon as possible and to carefully document any lessons learned. The analysis also indicates a need for considerable improvement in the collection of building energy data and the services performed in those efforts. Processes should be developed to enable mid-course corrections and enforce good data quality.

The energy conservation measures identified here will go a long way towards priming the market for energy efficiency services. However, the relatively conservative audit data under discussion only hints at the fact that there are even deeper savings to be found. More importantly, these findings also illuminate the scale of the challenge facing the building sector's meaningful contribution towards mitigating the climate crisis. Preparing New York City's buildings for the challenges ahead will require more analysis to map a pathway ensuring affordability and an equitable distribution of benefits for holistic retrofits of the existing building stock.

This conversation should engage all of our communities, not just policy makers and technical experts. Although

Photo: Bright Power

there are multiple barriers to progress, addressing the role of our buildings in the climate crisis brings a host of related benefits that contribute to a healthier, more affordable, and more resilient city. By advancing this discussion, New York City can further solidify its position of leadership in the global campaign to mitigate climate change.

glossary

ACS
American Community Survey

ASHRAE
American Society of Heating, Refrigerating, and Air-Conditioning Engineers

BBL
Borough, block, and lot

BMS
Building management system

BTU
British thermal unit (1 BTU)

> **kBTU**
> Kilo British thermal unit (1,000 BTU)
> **GBTU**
> Giga British thermal Unit (10^9 BTU, 10^3 KBTU)
> **TBTU**
> Tera British thermal unit (10^{12} BTU, 10^9 kBTU, 10^3 GBTU)

CHP
Combined heat and power

DHW
Domestic Hot Water

ECM
Energy conservation measure

EUI
Energy use intensity

GGBP
Greener, Greater, Buildings Plan

HCR
New York State Homes and Community Renewal

HDC
Housing Development Corporation

HPD
Department of Housing, Preservation, and Development

HUD
Housing and Urban Development

HVAC
Heating, ventilation, and air conditioning

kW
Kilowatt

kWh
Kilowatt Hour

LIHTC
Low-income Housing Tax Credit

MOS
Mayor's Office of Sustainability

NYCEEC
New York City Energy Efficiency Corporation

NYCHA
New York City Housing Authority

NYPA
New York Power Authority

NYSERDA
New York State Energy Research and Development Authority

O&M
Operations and maintenance

REV
Reforming the Energy Vision

RCM
Retro-commissioning measures

SHIP
Subsidized Housing Information Project

WAP
Weather Assistance Program

Building Management System (BMS)
Building management systems are computer-based systems that help manage, control, and monitor building technical services and the energy consumption of devices used by that building. They provide information and tools needed to understand the energy usage of a building and to control and improve a building's energy performance. These are sometimes referred to as **Energy Management Systems (EMS)**.

Covered Buildings
Covered buildings refer to all buildings that must comply with the New York City Greener, Greater Buildings Plan. These are buildings over 50,000 square feet or multiple buildings on a single property totaling over 100,000 square feet.

Domestic Hot Water (DHW)
Domestic hot water is water used for domestic purposes. Primarily, this includes drinking, food preparation, sanitation, and personal hygiene. The three types of DHW available are boiler, gas, and electric.

Energy Use Intensity (EUI)
Energy Use Intensity (EUI) expresses a building's energy use as a function of its size or other characteristics. EUI is expressed as energy per square foot per year, and is calculated by dividing the total energy consumed by the building in one year (typically measured by kBtu) by the total gross floor area of the building.

Greener, Greater Buildings Plan (GGBP)
Greener, Greater Buildings Plan (GGBP) is a comprehensive effort that targets energy efficiency in 15,000 properties over 50,000 square feet. GGBP consists of four pieces of regulation (2010 Local Laws 84, 86, 87, and 88) supplemented with job training and financing opportunities. This initiative is designed to insure that information about energy is provided to decision-makers and that the most cost-effective energy efficiency measures are pursued.

Heating, Ventilation, and Air conditioning (HVAC)
HVAC refers to the different systems, machines, and technologies used in indoor settings to provide air quality and thermal control (heating and cooling) services.

Energy Benchmarking and Disclosure Law, Local Law 84 (LL84)
Local Law 84 (LL84) requires annual benchmarking of energy and water consumption for all properties with over 50,000 square feet, or properties with multiple buildings totaling over 100,000 square feet. This law is part of the Greener, Greater Buildings Plan.

Energy Audit and Retro-commissioning Law, Local Law 87 (LL87)
Local Law 87 (LL87) requires an ASHRAE level 2 energy audit and performing retro-commissioning once every 10 years for all properties with over 50,000 square feet, or properties with multiple buildings totaling over 100,000 square feet. This law is part of the Greener, Greater Buildings Plan.

Lighting and Submetering Law, Local Law 88 (LL88)
Local Law 88 (LL88) applies to all properties with over 50,000 square feet, or properties with multiple buildings totaling over 100,000 square feet. It requires that by 2025 the lighting in the non-residential space be upgraded to meet code and large commercial tenants be provided with sub-meters. This law is part of the Greener, Greater Buildings Plan.

Mitchell Lama
Mitchell Lama housing is affordable rental and cooperative housing for moderate- and middle-income families. There are approximately 54,000 Mitchell Lama units in132 publically-sponsored rental and cooperative developments in New York City. The Mitchell Lama Housing Program was signed into law in 1955.

New York City Housing Authority (NYCHA)
The New York City Housing Authority (NYCHA) is a department of the New York City Government whose mission is to provide safe, affordable housing for low- and moderate-income New Yorkers. More than 400,000 New Yorkers live in NYCHA's 334 public housing developments around the five boroughs.

Passive House
Passive House refers to a rigorous, voluntary standard for energy efficiency in a building. A building constructed using passive house principles is very well insulated, virtually air-tight and primarily heated externally via solar energy and internally from building occupants, electrical equipment, etc. Any remaining heating or cooling demand is provided by an extremely small source, and balanced fresh air is constantly supplied. This standard saves up to 90 percent of heating and cooling costs, and provides high indoor air quality.

Photovoltaic
Photovoltaic systems convert sunlight into electricity. Installing photovoltaic systems can help save energy costs by reducing the need to purchase electricity from a utility. Moreover, any excess electricity produced that a building does not use is sold to the utility in a process called net-metering.

Reforming the Energy Vision (REV)
Reforming the Energy Vision (REV) is a New York State initiative designed to lead to regulatory changes that promote more efficient use of energy, deeper penetration of renewable energy resources, such as wind and solar, and wider deployment of "distributed" energy resources, such as micro grids, on-site power supplies, and storage.

Retro-commissioning Measures (RCM)
Retro-commissioning is the testing and tune-up of existing building systems to confirm that they are operating as designed and as efficiently as possible. Retro-commissioning commonly identifies maintenance, calibration, and operation errors that are easily corrected and, when implemented, save energy and improve equipment reliability.

Section 8 Housing
Section 8 Housing (also referred to as the Housing Choice Voucher Program) is a federally-funded program that provides rental assistance to eligible low-income families to find affordable housing in the private rental market. Approximately 29,000 owners participate in the program.

Site Energy vs. Source Energy
Source energy represents the total amount of raw fuel that is required to operate a building. This incorporates all transmission, delivery, and production losses. Site energy is the amount of heat and electricity consumed by a building as reflected in one's utilities bill. Site energy can be delivered to a building as primary or secondary energy. Primary energy is the raw fuel that is burned to create heat and electricity. Secondary energy is the energy product created from raw fuel.

Subsidized Housing Information Project (SHIP)
The Subsidized Housing Information Project (SHIP) is a database maintained by the NYU Furman Center. It brings together multiple data sources to provide financial and physical information about nearly 235,000 units of privately owned, subsidized rental properties in New York City.

list of graphics

Figures

Tables

Maps

Sidebars

appendices

A

Existing Resources

Several programs currently exist in New York City to advance energy efficiency and reduce greenhouse gas emissions, particularly in multifamily buildings. These include:

NYC Carbon Challenge Multifamily Group
A group of multifamily building owners and property managers who have committed to aggressive carbon reduction goals and share knowledge and experiences.

Clean Heat Program
Mandates building conversion from heavy or "dirty" Oil (#4 and #6) to either #2 oil or natural gas.

Utility programs
Programs from Con Edison and National Grid that provide incentives for energy efficiency retrofits in multifamily buildings.

NYSERDA Multifamily Performance Program (MPP)
Provides funding for energy audits, the development of Energy Reduction Plans and the implementation of Energy Conservation Measures in multifamily properties

New York City Energy Efficiency Corporation (NYCEEC)
Provides innovative financing for energy efficiency retrofits.

NYC Department of Housing Preservation and Development Green Preservation Program
Provides financing to landlords in affordable areas for energy efficient retrofits.

Weather Assistance Program (WAP)
Assists income-eligible families and individuals by reducing their heating and cooling costs and addressing health and safety issues in their homes through energy-efficiency measures. This is a federally funded program, administered by the Department of Housing and Urban Development in New York.

NYC Toilet Replacement Program
Provides rebates to multifamily buildings owners for installing low-flow toilets.

NYCHA Energy Efficiency Retrofits
To date, NYPA has financed more than 1,000 energy efficiency projects in NYCHA housing. Measures financed include boiler replacement, upgraded lighting and controls, and retrofitting steam systems.

NYC Green House Website
This website, developed by the Department of Housing Preservation and Development, provides information on energy efficiency tools and financing to tenants and building owners.

B

Methodology

Methodology of Benchmarking Law and the Energy Audit Law Cleaning and Analysis for *Retrofitting Affordability*

The data cleaning and analysis described below is specific to the scope of the *Retrofitting Affordability* report. Our efforts were focused solely on the fields relevant to this study (those relating to location, age, area, building type, primary heating fuel, and energy conservation measures). For any further analysis beyond the scope, further cleaning is needed.

Tools & Datasets
The cleaning and analysis was performed using Python programming in the Pandas library, a standard library for manipulating large datasets that contain both numerical and text information. Python was chosen for this analysis because it has a repeatable methodology that could be employed on subsequent annual dataset submissions. Both Pandas and Python are freely available.

The datasets were received from the New York City Mayor's Office of Sustainability (MOS). Two datasets were used for this analysis, the Benchmarking Law (Local Law 84, LL84) data and the Energy Audit Law (Local Law 87, LL87) data, both from 2013. The LL84 dataset used contained 12,805 benchmarking submissions. Subsequently, 357 NYCHA submissions were replaced with an improved set of 296 NYCHA campus submissions, resulting in a final total of 12,744 records. The LL87 dataset used contained 1,430 energy audits submitted to the City in 2013. It also contained 333 "early submission" audits, but these were not used due to their different report formats. Both the LL84 and the LL87 datasets required substantial data cleaning, and efforts focused solely on the fields relevant to this study. Additional cleaning is needed to include any further fields for any other analysis.

Energy Audit Law (Local Law 87) Data Cleaning
For the initial exploration and subsequent analysis the following fields were corrected for misspelling, spurious whitespace and variations in capitalization, and corrections were performed using find/replace or in some cases regular expression matching:

- Borough
- Early compliance
- Gross floor area
- Central distribution type
- Number of above grade floors
- Measure name × 25 fields
- Category × 25 fields

Duplicate entries were then removed. There were 5 perfect duplicates of every field. 27 entries with duplicate BBL (Borough, Block, Lot) and BINs (Building Identification Numbers) were removed keeping only the most recent entry. This may eliminate some properties with reasonable data but it was not possible to investigate these further within the scope of this study.

Table 11 shows the groupings for the property labels used in this analysis. Properties that did not contain the required fields for labeling were eliminated from the analysis.

Finally, the results were limited to just multifamily based on the "facility type" field. This left a total of 873 LL87 properties still under consideration.

Benchmarking Law (Local Law 84) Data Cleaning
The LL84 dataset fields required no specific spelling or whitespace fixes due to these data being sourced from the Portfolio Manager submissions, which enforces dropdown selection and field entry restrictions. The authors and other leading auditor companies highly recommend a similar system be developed for LL87 data going forward.

The LL84 dataset, however, does suffer from some other data quality issues, stemming from the more diverse group of people who enter this information. This study followed similar data cleaning procedures to previous studies that included:

- Removal of non-NYC zipcodes. (107 sites)
- Removal of sites where the "Property Floor Area" was missing or zero. (86 sites)
- Removal of sites where the Source EUI was greater than 1000 or less than 5. (1,387 sites)
- Removal of perfect duplicate submissions. (9 sites)
- Removal of duplicated BBL

Table 11: Energy Audit Law (LL87) Sorting Criteria

Category	Label	Criteria
Age	Pre-War	Year of construction/substantial Rehabilitation < 1947
	Post-War	Year of construction/substantial Rehabilitation ≥ 1947
Height	Low-rise	Number of above grade floors ≤ 7
	Mid-rise	7 < Number of above grade floors ≤ 19
	High-rise	# of above grade floors > 19
Primary Heating Fuel	Electric	Heating System 1/Fuel Sources = Electricity
	Gas	Heating System 1/Fuel Sources = Natural Gas OR Heating System 1/Fuel Sources = Dual Fuel AND Natural Gas/Space Heating > Fuel Oil/Space Heating
	Oil	Heating System 1/Fuel Sources = #2/#4/#6 Oil OR Heating System 1/Fuel Sources = Dual Fuel AND Fuel Oil/Space Heating > Natural Gas/Space Heating
	Steam	Heating System 1/Fuel Sources = District Steam

Table 12: Benchmarking Law (LL84) Sorting Criteria

Category	Label	Criteria
Age	Pre-War	Year built < 1947
	Post-War	Year built ≥ 1947
Height	Low-rise	Multifamily Housing – Maximum Number of Floors ≤ 7
	Mid-rise	7 < Multifamily Housing - Maximum Number of Floors ≤ 19
	High-rise	Multifamily Housing – Maximum Number of Floors > 19
Primary Heating Fuel	Electric	% of Site Energy that is Electricity > (1 – Heating Threshold)
	Gas	% of Site Energy that is Gas > Heating Threshold*
	Oil	% of Site Energy that is Oil (#2,#4,#6) > Heating Threshold*
	Steam	% of Site Energy that is Steam > Heating Threshold*

submissions. This may have eliminated some properties with reasonable data but it was not possible to investigate these further within the scope of this study. (603 sites)

- Removal of sites with EUIs in the 1st and 99th percentile. The cutoffs calculated were 1st : 23.4kBTU/sqft/year, 99th : 321.6 kBTU/sqft/year for multifamily properties. (186 sites)
- These steps removed 2,378 properties, resulting in 10,426 properties remaining.
- Only multifamily properties were considered in this study, these were determined from the “Primary Property Type - Self Selected” field. This left 7,934 multifamily properties
- In cases where properties did not have the 'Multifamily Housing - Maximum Number of Floors' field completed, this was retreived from the PLUTO dataset. For properties with multiple BBLs, the highest number of floors was used.
- Properties that did not contain the required fields for labeling were eliminated from the analysis. (203 sites)This left a total of 7,731 LL84 properties still under consideration.

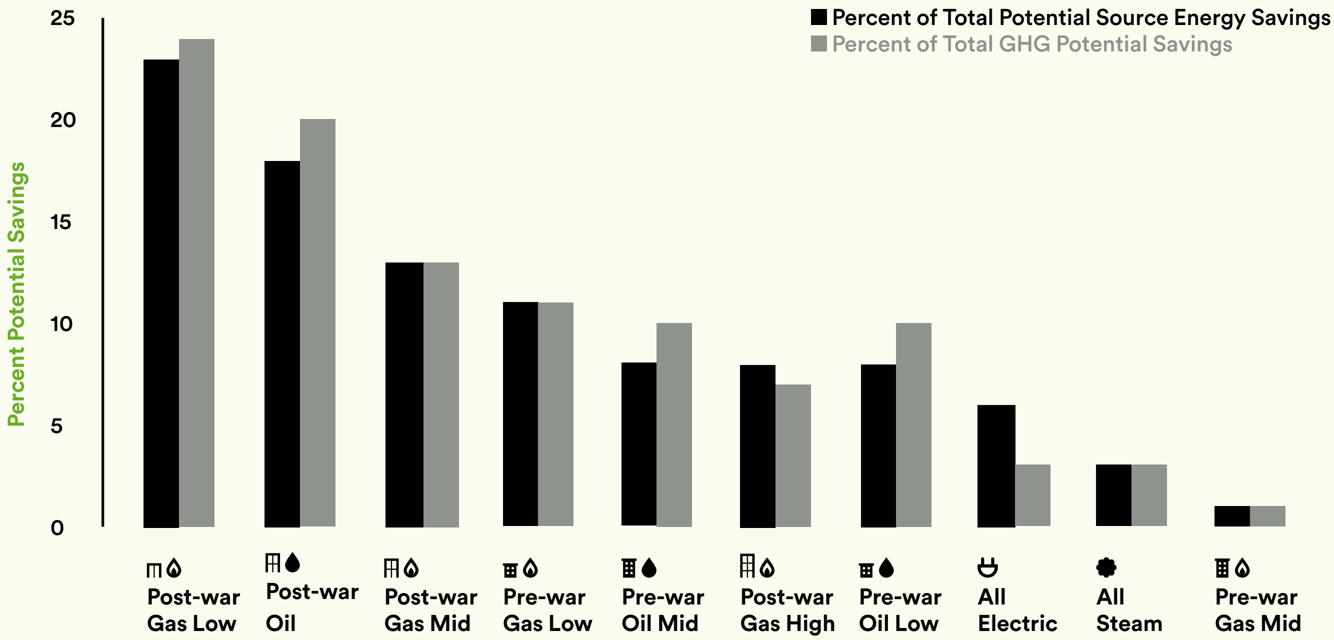
Please see Table 12 for the labels to allow for grouping for analysis.

Comparing the Two Labeled Data Sets

In order to extrapolate from the findings in the LL87 dataset to the LL84 dataset it was necessary to confirm that the labeled datasets contained no large systematic discrepancies. Figure 12 below shows the comparison the LL84 and LL87 datasets for each of the chosen label categories.

Upon inspection, there is reasonably good agreement between the two sets. A Pearsons’s Chi-squared test was performed on each group to test the null hypothesis that these two sets were drawn from the same population of buildings. The age distribution shows reasonably good agreement between the two sets ($p = 0.057$), and does not reject the null hypothesis. However both

Figure 12: Comparison of Percent Potential Source Energy Savings and Potential GHG Reductions



Percent of potential source energy savings and potential green house gas reduction are very similar. Therefore, throughout the report, source energy savings are highlighted.

the building height (p = 0.003) and the heating fuel (p = 0.000) do reject the null hypothesis, implying the differences shown in those charts are statistically significant. This likely has the biggest impact on the All Electric group where the methodology for determining heating fuel may be slightly biased towards labeling Electricity. As such, the analysis may over-estimate the impact of ECMs in All Electric buildings. However, given that these are a relatively small group, this does not invalidate the overall analysis.

The other noticeable trend is that LL87 reported a lower percentage of "High" buildings. However, in the final analysis, the High, pre-war groups ended up being excluded due to having too few properties in the LL87 set. Since there are not many "high" buildings in LL84 nor LL87, the impact of not including the "high" pre-war buildings is small on the overall analysis.

Estimation of Impact

In order to estimate the energy savings potential of the New York City multifamily building stock of properties over 50,000 SF, the authors took the following steps.

- Labeled every valid LL87 property with the above segment labels.
- Calculated the average percentage site energy savings of each Measure Type and Segment combination.
- Eliminated any measures that were recommended fewer than 3 times in a particular segment. Measures that projected over 20% savings for that single measure were also eliminated (this only eliminated two examples).
- Calculated the frequency of recommendation of each Measure Type by Segment.
- Combined those two values to determine the real energy savings potential expectation value for that Measure/Segment combination.
- Multiplied that expectation value by the total encompassed site energy for each segment to determine the energy savings potential for that Measure/ Segment combination if it were applied to the LL84 building stock.
- Determined the site to source conversion factor and site to carbon conversion factor for each LL84 segment type and applied those factors to the site energy savings potential to determine the source and carbon savings potentials.
- Aggregated all the potential savings by segment.
- Scaled up the results from the total number of labelled LL84 properties to the total number of multifamily buildings on the covered building list, to determine the citywide savings potential.

Though many assumptions were made to estimate the theoretical impact, the authors believe these assumptions are defensible. The source energy estimate of 192.7 million GJ for all large multifamily buildings is in close agreement to 187.5 million GJ, the number reported in *2012 Inventory of Greenhouse Gas Emissions for "Residential Large."* This check gives confidence to the methodology.

The general assumptions made to facilitate the above are:

- The frequency a measure is recommended in LL87 for a given segment will remain valid for the same segment in the LL84 set.
- The average percent savings for a given measure in LL87 for a given segment will remain valid for the same segment in the LL84 set.

The LL87 dataset is a little more than 10% of the LL84 properties, which is a reasonable sampling level to make assumptions about the relationship between LL84 and LL87 datasets.

- The analysis assumes the fuel mix in each individual LL84 segment is indicative of the fuel mix in the LL87 segments, which allows the use of the same site to source and site to carbon conversions. This assumption is due to the very poor data quality in the individual fuel totals in the LL87 data for both the measure impact and the overall building energy. A more rigorous data collection scheme for LL87 would remove the need for this assumption.

- Finally, the distribution of buildings by segment in the LL84 set is assumed to be indicative of the distribution of all multifamily buildings over 50,000 SF. This seems a reasonable assumption given that the LL84 labeled set is sampling 7,731/10,043 or about 77% of all potential buildings.

As future years of LL87 data are submitted, it will be possible to assess the validity of these assumptions and update the projected energy and carbon savings potential appropriately. Each year 10% more of the New York City building stock will be sampled, resulting in a high percent coverage of the LL87 data.

C

Greenhouse Gas and Source Energy Conversions

Discussing the impacts of different greenhouse gas coefficients on estimating emissions.

Since the launch of PlaNYC in 2007, the City has been preparing annual Greenhouse Gas Emissions (GHG) Inventories, with advances in the methodologies each year. New York City's emissions calculation methodology differs from the standardized reporting developed by the US Environmental Protection Agency (EPA) which is used in reporting building energy performance through the Energy Star Portfolio Manager system. All of the Benchmarking Law reporting and data analysis in the annual Benchmarking Reports by the City (done through the Portfolio Manager system) uses the EPA methodology for data analysis, which reports total direct and indirect greenhouse gases emitted due to energy used by the property in metric tons of carbon dioxide equivalent (mtCO2e). The Energy Star carbon coefficient is based on NYC's EPA Emissions & Generation Resource integrated Database (eGRID) sub-region.

The different methodology used in the annual NYC GHG inventory reports accounts more accurately for usage within the five boroughs of NYC alone, and also includes more recent electricity generation data, including electricity imported into New York City. Similarly, NYC calculates the emissions factors for district steam on a local basis, different from EPA's national methodology. A detailed description of the emissions calculations methodology is provided in the Appendices of each year's NYC GHG Inventory report.

Because Retrofitting Affordability relies heavily on the LL84 data compiled by the City, it uses the EPA Energy Star emissions and source energy conversion factors ("source" energy is the amount of energy needed to create all the energy consumed on the site, and takes into account, for example, energy lost due to the generation and transmission of electricity). The variations between the EPA methodology and the NYC factors are relatively minor: the electricity emissions factors vary by less than 3% between the two methodologies, while the site/source energy calculations differ by less than 7%. As such, this report stays consistent with all the LL84 reporting, but has a small discrepancy with the larger, city scale NYC GHG Inventory.

D

Data Challenges – Collecting Quality Audits

Meaningful, impactful analysis is predicated on having highthe quality of the data under scrutiny.

In the case of this study, the two primary data sets are from the Benchmarking Law (Local Law 84) data and the Energy Audit Law (Local Law 87) data. The Benchmarking Law dataset is 10 times larger, which means that it would take significantly more poor quality data points to affect the overall quality of the analysis. Also, now that Benchmarking Law data has been submitted for several years, some many of the original early data quality issues in the first year of submission have been corrected through education of both the submitters and the recipients of the data. The Energy Audit Law data analyzed here is the first year of submitted data, and thus there were many data quality issues within the relatively small data set. As a result, our team exercised significant caution in the analysis of this report. Several Local Law 87 data issues are outlined below:

Data Standardization

The Energy Audit Law (Local Law 87) requires buildings to perform an energy audit and organize a separate retro-commissioning process. This mandate results in two sets of information, energy conservation measures (ECMs, from the audits) and retro-commissioning measures (RCMs), which are compiled into a single report. Missing from this analysis is the energy, cost and GHG savings impact of the required retrocommissioning measures.

Unfortunately, the data currently available on RCMs was not available in a useable form or sufficient quality for useful analysis. Many of the RCMs in the data did not have the required savings estimates associated with them. There also appeeared to be disagreement among different auditors as to whether certain measures belonged in the ECM or the RCM categories; therefore measure recommendation tallies may be inaccurate, making even a simple count of a particular measure difficult.

City Expectations

While the City provided more specific guidance on the RCMs to be included in LL87, the energy audit recommendations were left to the professional discretion of the auditor. Two engineers asked to solve a fairly open-ended problem (e.g. "how would you make this better?") will give very different answers, and this holds true for the individuals performing the Energy Audit Law work: lighting experts are more likely to find lighting measures, heating experts are more likely to find heating measures, etc. As a result, there is no clear threshold of whether a set of recommendations is comprehensive enough to satisfy the law. Particularly in situations where the building owner looks at the Energy Audit Law as just another compliance requirement, there is very little motivation for the auditor to do any more than the bare minimum.

Training and Experience Level of Auditors

There was general concern among the authors and the advisory committee that the range of experience among energy auditors might lead to wide variation in the quality of ECM recommendations. A deeper concern, shared by members of this group, is that the skill level and knowledge of some individuals performing LL87 audits is questionable, meaning that some recommended measures are limited and/or inappropriate. Furthermore, in order to maximize the benefit of LL87 for the city, and achieve projected savings, it is vital that complete recommendations are made. For example, a heating control system (EMS) should be upgraded in conjunction with balancing the heating system, but this type of thorough recommendation was often not seen clearly in LL87 data, raising the potential for projects to fall short of projected savings.

Over-Represented Measures

Specifically, "Domestic Hot Water – Separate Domestic Hot Water" and "Envelope – Replace Windows" appear to be over-represented in the recommended ECMs based on the author's experience. For instance, installing a separate domestic hot water system can be a very effective measure for certain larger buildings, especially those running on oil. However, it is not nearly as universally applicable as many auditors appear to think. This could be due to underestimated costs or overestimated savings.

Missing Measures

ECMs related to heating upgrades were expected to provide the greatest amount of savings, which was expected, because the heating typically consumes two-thirds of the fossil fuel used by a New York City building, and heating systems commonly have substantial room for efficiency gains. However, the savings estimates overall were not as high as expected for this category. This may be driven by measures that were missed entirely, were not cataloged in the cleaning methodology, or were included under retro-commissioning, rather than energy conservation measures. Such measures include: heating system balancing, steam traps, air valves, pump controls, outdoor reset controls, reducing overheating.

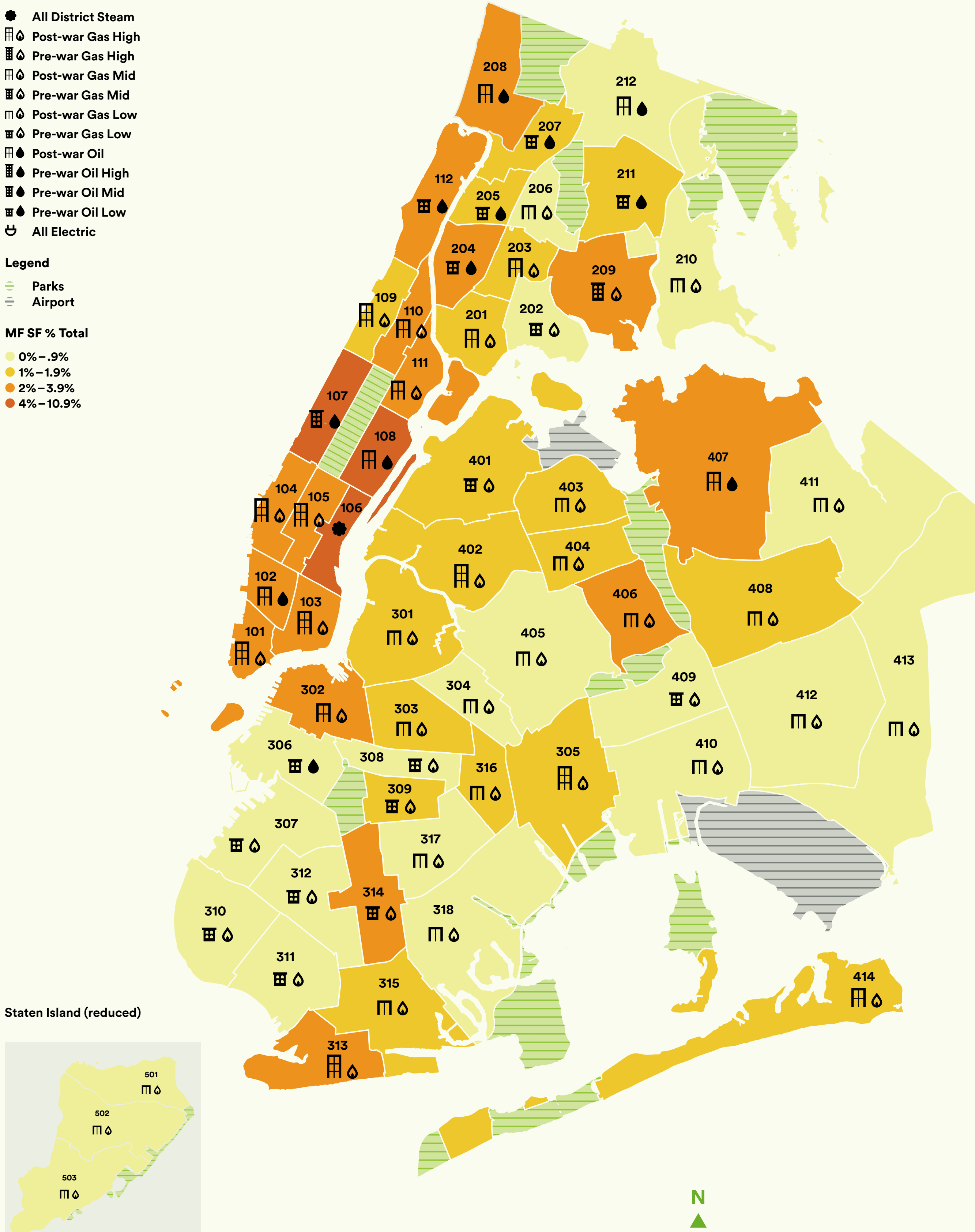
The authors suggest further analysis of these and related issues by the NYC Department of Buildings (DOB) in order to create guidelines for evaluating audits, and recommend ensuring that the highest energy end uses (typically heating) have sufficient energy conservation measures associated with them. Additionally, the provision of increased training and information for the practitioners would to help standardize audits.

maps

Index of Community Districts

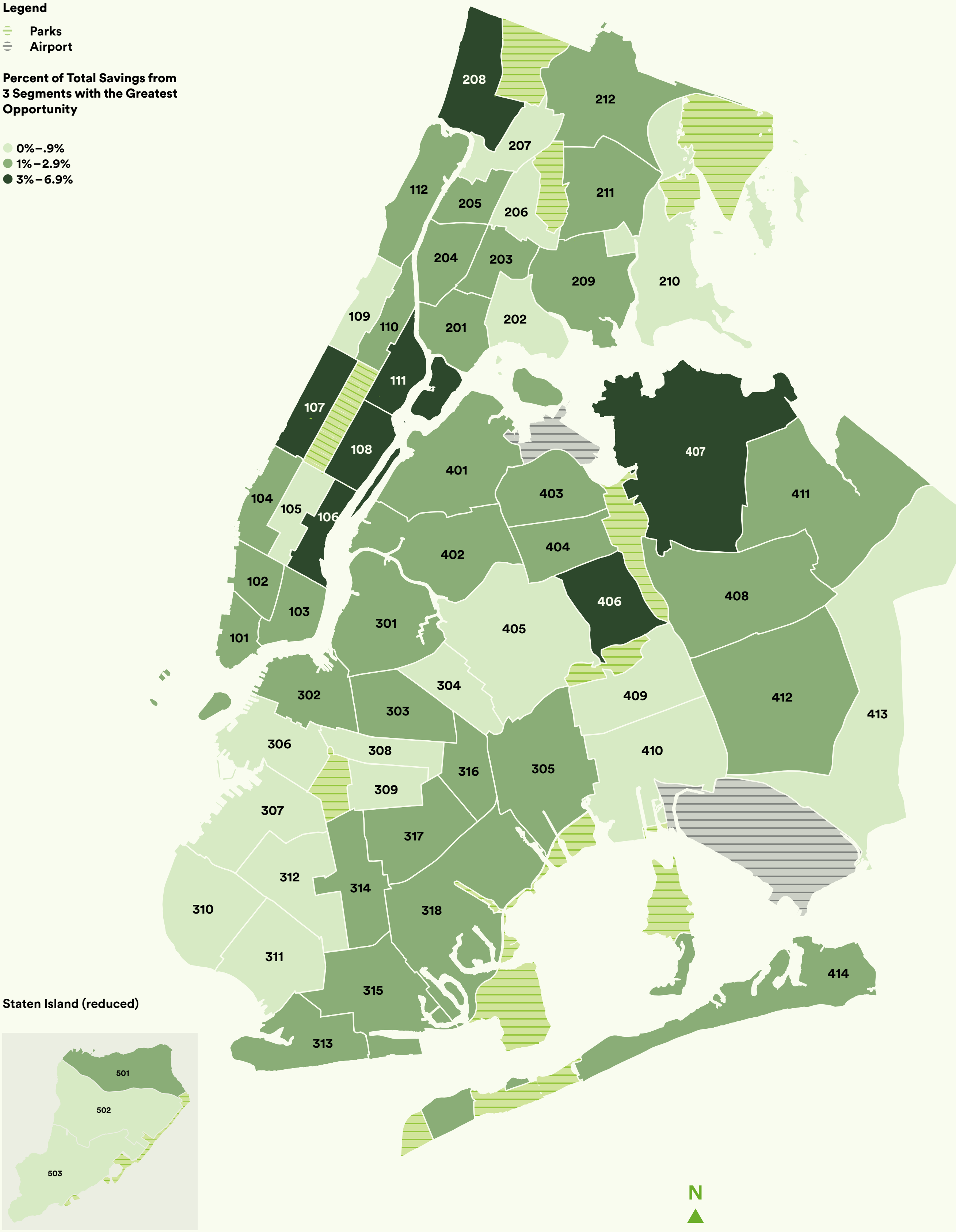
CD #	Borough	Neighborhood
101	Manhattan	Financial District
102	Manhattan	Greenwich Village/Soho
103	Manhattan	Lower East Side/Chinatown
104	Manhattan	Clinton/Chelsea
105	Manhattan	Midtown
106	Manhattan	Stuyvesant Town/Turtle Bay
107	Manhattan	Upper West Side
108	Manhattan	Upper East Side
109	Manhattan	Morningside Heights/Hamilton
110	Manhattan	Central Harlem
111	Manhattan	East Harlem
112	Manhattan	Washington Heights/Inwood
201	Bronx	Mott Haven/Melrose
202	Bronx	Hunts Point/Longwood
203	Bronx	Morrisania/Crotona
204	Bronx	Highbridge/Concourse
205	Bronx	Fordham/University Heights
206	Bronx	Belmont/East Tremont
207	Bronx	Kingsbridge Heights/Bedford
208	Bronx	Riverdale/Fieldston
209	Bronx	Parkchester/Soundview
210	Bronx	Throgs Neck/Co-Op City
211	Bronx	Morris Park/Bronxdale
212	Bronx	Williamsbridge/Baychester
301	Brooklyn	Greenpoint/Williamsburg
302	Brooklyn	Fort Greene/Brooklyn Heights
303	Brooklyn	Bedford-Stuyvesant
304	Brooklyn	Bushwick
305	Brooklyn	East New York/Starrett City
306	Brooklyn	Park Slope/Carroll Gardens
307	Brooklyn	Sunset Park
308	Brooklyn	Crown Heights/Prospect Heights
309	Brooklyn	S. Crown Heights/Lefferts Gardens
310	Brooklyn	Bay Ridge/Dyker Heights
311	Brooklyn	Bensonhurst
312	Brooklyn	Borough Park
313	Brooklyn	Coney Island
314	Brooklyn	Flatbush/Midwood
315	Brooklyn	Sheepshead Bay
316	Brooklyn	Brownsville
317	Brooklyn	East Flatbush
318	Brooklyn	Flatlands/Canarsie
401	Queens	Astoria
402	Queens	Woodside/Sunnyside
403	Queens	Jackson Heights
404	Queens	Elmhurst/Corona
405	Queens	Ridgewood/Maspeth
406	Queens	Rego Park/Forest Hills
407	Queens	Flushing/Whitestone
408	Queens	Hillcrest/Fresh Meadows
409	Queens	Kew Gardens/Woodhaven
410	Queens	S. Ozone Park/Howard Beach
411	Queens	Bayside/Little Neck
412	Queens	Jamaica/Hollis
413	Queens	Queens Village
414	Queens	Rockaway/Broad Channel
501	Staten Island	St George/Stapleton
502	Staten Island	South Beach/Willowbrook
503	Staten Island	Tottenville/Great Kills

Map 9: Distribution of Covered Multifamily Buildings in New York City, Showing Segment with Greatest Area by Community District



This map shows the distribution of the distribution of all New York CIty covered multifamliy buildings. The icon represent the segment with the greatest square footage in that community district.

Map 10: Distribution of Source Energy Savings from Three Segments with the Greatest Opportunity



Map 10 shows the distribution of the energy savings potential from the three largest segments, Post-War Oil, Post-War Gas Low-rise and Post-War Gas Mid-rise. The darker community districts have the greatest energy savings potential.

Table 13: ECMs Organized by Greatest Energy Savings by Segment: This table compares the energy savings, cost per square foot and payback of the five ECMs with the greatest potential energy savings in each segment. This table can help inform a package of retrofits that may be suitable for each individual segment.

Energy Conservation Measure	Potential Source Energy Savings (GBTU*)	Frq. of Recs	Cost per SF		Cost per Unit		Payback (years)
All Electric							
Replace Windows	500	36%	$2.85	$$$$	$3,453.31	$$$$	11.0
Install Low-Flow Aerators	260	45%	0.32	$$$	$392.02	$$$	3.0
Upgrade DHW Boiler	130	36%	0.22	$$	$269.87	$$$	9.2
Motors – Install VFDs	120	45%	0.06	$$	$69.52	$$	2.9
Upgrade to LED	80	164%	0.06	$$	$67.92	$$	2.5
All District Steam							
Replace with LED	210	20%	$0.01	$	$10.61	$	3.8
Other – Other	160	14%	$0.14	$$	$189.58	$$$	6.0
Install or Upgrade EMS/BMS	130	10%	$0.14	$$	$185.05	$$$	0.8
Sealing - Door	70	10%	$0.02	$	$27.30	$$	1.4
Install Exhaust Fan Timers	30	8%	$0.01	$	$15.57	$	0.9
Post-war Gas Low							
Separate DHW from Heating	1000	44%	$0.30	$$$	$301.72	$$$	6.7
Install or Upgrade EMS/BMS	630	22%	$0.26	$$$	$260.29	$$$	3.8
Install Low-Flow Aerators	500	29%	$0.08	$$	$79.19	$$	3.0
Upgrade Burner	390	25%	$0.25	$$	$247.39	$$$	6.7
Replace Boiler	240	4%	$0.71	$$$	$705.63	$$$$	20.2
Post-war Gas Mid							
Heating System - Other	760	28%	$1.10	$$$$	$1,120.00	$$$$	3.7
Install or Upgrade EMS/BMS	190	9%	$0.26	$$$	$263.14	$$$	3.5
Separate DHW from Heating	190	17%	$0.60	$$$	$613.22	$$$$	10.5
Upgrade Boiler	180	12%	$1.28	$$$$	$1,305.43	$$$$	26.6
Upgrade Burner	160	9%	$0.45	$$$	$456.92	$$$	7.4
Post-war Gas High							
Install or Upgrade EMS/BMS	650	15%	$0.33	$$$	$377.24	$$$	3.3
Separate DHW from Heating	350	26%	$0.29	$$$	$333.53	$$$	9.3
Other	160	22%	$0.09	$$	$98.97	$$	5.7
Install Low-Flow Aerators	140	19%	$0.07	$$	$75.85	$$	3.9
Insulate Pipes	140	30%	$0.03	$	$37.13	$$	3.6

Legend

- Domestic Hot Water
- Heating & Distribution
- Ventilation & Cooling
- Envelope
- Lighting
- Fuel Switching
- Other

Cost per Square Foot	
$	< $0.05
$$	$0.05-$0.25
$$$	$0.26-$1.00
$$$$	> $1.00

Cost per Unit	
$	< $20.00
$$	$20.00-$100.00
$$$	$100.01-$500.00
$$$$	> $500

Payback (years)
0–3
3.1–5
5.1–10
10.1–100

Energy Conservation Measure	Potential Source Energy Savings (GBTU*)	Frq. of Recs	Cost per SF		Cost per Unit		Payback (years)
Post-war Oil							
Separate DHW from Heating	570	24%	$0.60	$$$	$624.34	$$$$	6.5
Increase Insulation - Floor	570	41%	$1.44	$$$$	$1,494.79	$$$$	4.0
Increase Insulation - Roof	500	19%	$3.61	$$$$	$3,748.38	$$$$	22.4
Envelope - Other	420	19%	$0.19	$$	$202.13	$$$	1.9
Replace Windows	180	19%	$0.08	$$	$82.53	$$	2.0
Pre-war Gas Low							
Separate DHW from Heating	340	33%	$0.48	$$$	$500.14	$$$$	11.7
Install or Upgrade EMS/BMS	320	15%	$0.23	$$	$240.59	$$$	2.3
Install Low-Flow Showerheads	210	6%	$0.04	$	$42.71	$$	3.1
Install Low-Flow Aerators	190	27%	$0.06	$$	$64.91	$$	3.0
Add Window Films	190	18%	$0.83	$$$	$ 876.65	$$$$	22.1
Pre-war Gas Mid							
Install TRVs	60	19%	$0.38	$$$	$ 451.62	$$$	8.5
Separate DHW from Heating	60	19%	$0.60	$$$	$703.24	$$$$	14.5
Install Low-Flow Aerators	40	29%	$0.05	$	$53.94	$$	5.00
Motors – Install VFDs	30	19%	$0.18	$$	$210.14	$$$	3.9
Insulate Pipes	30	32%	$0.04	$	$41.45	$$	2.2
Pre-war Oil Low							
Install or Upgrade EMS/BMS	280	20%	$0.28	$$$	$298.03	$$$	1.8
Separate DHW from Heating	250	28%	$0.62	$$$	$662.64	$$$$	7.8
Replace Windows	190	18%	$3.03	$$$$	$3,245.20	$$$$	36.3
Install Low-Flow Aerators	120	28%	$0.06	$$	$61.81	$$	2.4
Install Indoor Sensors	110	9%	$0.37	$$$	$398.89	$$$	2.4
Pre-war Oil Mid							
Separate DHW from Heating	260	38%	$0.55	$$$	$855.15	$$$$	9.1
#2 Oil to Natural Gas	200	8%	$2.19	$$$$	$3,428.19	$$$$	4.3
Install or Upgrade EMS/BMS	170	17%	$0.21	$$	$325.55	$$$	2.4
#6 Oil or #4 Oil to Natural Gas	110	36%	$2.05	$$$$	$3,205.49	$$$$	5.0
Install Low-Flow Aerators	110	32%	$0.07	$$	$106.83	$$$	2.1

Legend

- Domestic Hot Water
- Heating & Distribution
- Ventilation & Cooling
- Envelope
- Lighting
- Fuel Switching
- Other

Cost per Square Foot		Cost per Unit		Payback (years)
$	< $0.05	$	< $20.00	0–3
$$	$0.05-$0.25	$$	$20.00-$100.00	3.1–5
$$$	$0.26-$1.00	$$$	$100.01-$500.00	5.1–10
$$$$	> $1.00	$$$$	> $500	10.1–100

Table 14: ECMs Organized by Greatest Energy Savings by Category: This table compares the energy savings, cost per square foot and payback of the ECMs in each category. This table can help identify ECMs that have can have a large citywide opportunity for energy reduction.

Energy Conservation Measure	Potential Source Energy Savings (GBTU*)	Frq. of Recs	Cost per SF		Cost per Unit		Payback (years)
Domestic Hot Water							
Separate DHW from Heating	3010	36%	$0.38	$$$	$415	$$$	5.8
Install Low-Flow Aerators	1650	31%	$0.12	$$	$132	$$$	2.0
Install Low-Flow Showerheads	310	4%	$0.04	$	$44	$$	1.3
Upgrade DHW Boiler	240	1%	$0.42	$$$	$491	$$$	7.3
Install DHW Controls	240	11%	$0.02	$	$17	$	0.6
Decrease DHW Temperature	150	6%	$0.00	$	$3	$	0.1
Other	120	5%	$0.12	$$	$133	$$$	4.8
Insulate DHW Piping	30	7%	$0.03	$	$38	$$	2.3
Envelope							
Replace Windows	1490	17%	$3.63	$$$$	$4,017	$$$$	17.8
Increase insulation – Roof	560	20%	$0.72	$$$	$753	$$$$	18.2
Add Window Films	500	12%	$0.69	$$$	$732	$$$$	14.0
Other	190	6%	$0.51	$$$	$593	$$$$	13.2
Sealing – Door	160	30%	$0.02	$	$27	$$	4.9
Sealing – Room AC	80	6%	$0.09	$$	$88	$$	8.6
Increase insulation – Floor	30	1%	$0.25	$$$	$261	$$$	3.3
Sealing – Vertical Shafts	30	2%	$0.05	$$	$65	$$	4.3
Sealing – Windows	30	4%	$0.11	$$	$112	$$$	6.7
Increase insulation – Wall	-	1%	$0.09	$$	$137	$$$	5.0
Fuel Switching							
#6 Oil or #4 Oil to Natural Gas	740	65%	$1.59	$$$$	$1,830	$$$$	3.8
#2 Oil to Natural Gas	230	13%	$2.13	$$$$	$2,539	$$$$	3.4
#6 to Dual Fuel	100	18%	$2.42	$$$$	$2,778	$$$$	3.5
#6 Oil or #4 Oil to #2 Oil	-	4%	$0.20	$$	$216	$$$	3.1
Heating & Distribution							
Install or Upgrade EMS/BMS	2780	15%	$0.19	$$	$205	$$$	1.7
Heating System – Other	940	10%	$0.40	$$$	$428	$$$	3.6
Insulate Pipes	890	38%	$0.02	$	$26	$$	2.0
Replace Boiler	690	4%	$1.97	$$$$	$2,148	$$$$	12.8
Upgrade Burner	610	6%	$0.29	$$$	$292	$$$	5.3
Upgrade Boiler	310	2%	$1.00	$$$$	$1017	$$$$	15.6
Change Set Points /Setbacks	170	4%	$0.02	$	$17	$	0.9
Install / Upgrade Master Venting	150	1%	$0.08	$$	$76	$$	3.0

Legend

Domestic Hot Water
Heating & Distribution
Ventilation & Cooling
Envelope
Lighting
Fuel Switching
Other

Cost per Square Foot		Cost per Unit		Payback (years)
$	< $0.05	$	< $20.00	0–3
$$	$0.05-$0.25	$$	$20.00-$100.00	3.1–5
$$$	$0.26-$1.00	$$$	$100.01-$500.00	5.1–10
$$$$	> $1.00	$$$$	> $500	10.1–100

Energy Conservation Measure	Potential Source Energy Savings (GBTU*)	Frq. of Recs	Cost per SF		Cost per Unit		Payback (years)
Clean & Tune Boiler/Furnace	140	3%	$0.05	$	$53	$$	1.6
Distribution System – Other	130	2%	$0.19	$$	$222	$$$	3.5
Lighting							
Upgrade to LED	750	43%	$0.04	$	$42	$$	2.8
Upgrade to Fluorescent	280	20%	$0.27	$$$	$293	$$$	11.7
Other	190	13%	$0.07	$$	$73	$$	4.7
Install OccupancySensors	140	10%	$0.06	$$	$68	$$	5.4
Upgrade Exterior Lighting	60	7%	$0.03	$	$36	$$	3.7
Install Bi-level Lighting	40	3%	$0.08	$$	$76	$$	7.5
Install Photocell Control	-	1%	$0.04	$	$45	$$	3.7
Upgrade Exit Signs to LED	-	2%	$0.01	$	$12	$	2.5
Replace with LED	-	1%	$0.01	$	$12	$	3.1
Upgrade to Flourescent	-	0%	$0.00	$	$1	$	1.6
Other							
Motors – Install VFDs	280	20%	$0.14	$$	$174	$$$	2.3
Other – Other	160	12%	$0.18	$$	$193	$$$	8.3
Process and Plug Loads – Other	120	7%	$0.64	$$$	$743	$$$$	8.2
Submetering – Install Submetering	130	5%	$0.73	$$$	$737	$$$$	3.1
Motors – Upgrade Motors	40	33%	$0.05	$$	$54	$$	7.9
Install Solar/Photovoltaic	30	9%	$0.21	$$	$230	$$$	4.3
Replace Washing Machines	10	10%	$0.02	$	$27	$$	7.1
Motors – Remove Motors	-	4%	$0.02	$	$25	$$	1.2
Ventilation & Cooling							
Install TRVs	580	6%	$0.29	$$$	$329	$$$	5.6
Install Indoor Sensors	380	4%	$0.21	$$	$238	$$$	2.1
Ventilation – Other	340	34%	$0.15	$$	$159	$$$	6.4
Replace Chiller	210	5%	$3.12	$$$$	$4,257	$$$$	11.9
HVAC Controls and Sensors – Other	110	2%	$0.08	$$	$88	$$	1.4
Upgrade Exhaust Fans	110	17%	$0.29	$$$	$298	$$$	9.6
Install CAR Dampers	80	6%	$0.61	$$$	$611	$$$$	11.9
Install Exhaust Fan Timers	40	15%	$0.01	$	$10	$	1.0
Zone control upgrades	10	0%	$0.14	$$	$140	$$$	10.1
Cooling System – Other	-	8%	$0.16	$$	$221	$$$	6.3

Legend

Domestic Hot Water
Heating & Distribution
Ventilation & Cooling
Envelope
Lighting
Fuel Switching
Other

Cost per Square Foot		Cost per Unit		Payback (years)
$	< $0.05	$	< $20.00	0–3
$$	$0.05-$0.25	$$	$20.00-$100.00	3.1–5
$$$	$0.26-$1.00	$$$	$100.01-$500.00	5.1–10
$$$$	> $1.00	$$$$	> $500	10.1–100

endnotes

1 NYC Mayor's Office of Long Term Planning and Sustainability (OLTPS). (2014). *One City, Built to Last.* 22,25

2 OLTPS. (2013). *Inventory of New York City Greenhouse Gas Emissions.* 3

3 NYC Department of City Planning. Primary Land Use Tax Lot Output (PLUTO) data file (14v2).

4 OLTPS. (2013) *Inventory of New York City Greenhouse Gas Emissions*. 3

5 OLTPS. (2012). *New York City Local Law 84 Benchmarking Report*. 16

6 OLTPS. (2012). *New York City Local Law 84 Benchmarking Repor*t. 19

7 OLTPS. (2012). *New York City Local Law 84 Benchmarking Report*, 5

8 New York City Office of the Mayor & Glen, A. (2014). *Housing New York: A Five Borough, Ten Year Plan*.

9 United States Census Bureau. (2014). *New York City Housing and Vacancy Survey*.

10 The Rent Guidelines Board sets the allowable rent increase due to energy cost increases for rent stabilized units. http://www.nycrgb.org/

11 New York City Rent Guidelines Board. (2013) 2013 Price index of Operating Costs, 6-7. http://www.nycrgb.org/downloads/research/pdf_reports/pioc13.pdf Utility costs include electricity, natural gas, and water and sewer charges.

12 New York City Office of the Mayor & Glen, A. (2014). *Housing New York: A 5 Borough, 10 Year Plan*.

13 OLTPS. (2014). *One City: Built to Last*, 60

14 New York State Energy Planning Board. (2014). *Shaping the Future of Energy: New York State Energy Plan Volume 1*. Retrieved from: http://energyplan.ny.gov/Plans/2014

15 OLTPS. (2012). *New York City Local Law 84 Benchmarking Repor*t. 19

16 This includes all covered multifamily properties, whether or not they reported their data under the Energy Benchmarking Law (Local Law 84).

17 A contributing factor to the difference in calculation of greenhouse gas emissions may be that the New York City Greenhouse Gas Inventory defines large residential as a multifamily building over 5 units. This study defines large residential as a property greater than 50,000 SF. See also: OLTPS. (2014). Inventory of New York City Greenhouse Gas Emissions.

18 This correlates with several previous studies including: Bright Power, ed. Stewards of Affordable Housing for the Future (SAHF), (2014) Energy and Water Savings in Multifamily Retrofits; Steven Winter Associates (SWA) and New York City Energy Efficiency Corporation (NYCEEC), (2013) Energy Savings Potential Calculator for New York City Multifamily Buildings; SWA and HR&A Advisors, (2012) Recognizing the Benefits of Energy Efficiency in Multifamily Underwriting, for Deutsche Bank and Living Cities.

19 Housing information from: Metropolitan Council on Housing. (2014). New York City's Affordable Housing Programs.

20 Furman Center. (2015). Low Income Housing Tax Credit. Available at: http://furmancenter.org/institute/directory/entry/low-income-housing-tax-credit

21 Furman Center. (2011). *State of New York City Subsidized Housing 2011*, 8.

22 Furman Center. (2011). *State of New York City Subsidized Housing 2011*, 6; Table 1B

23 For a detailed explanation of the characteristics chosen, please refer to Appendix A: Methodology.

24 This analysis excludes Pre-War High rise segments because there was not a representative sample in the Energy Audit Law (local Law 87) data.

25 See Consolidated Edison's Request for Information here: http://www.coned.com/energyefficiency/pdf/Demand_Management Project_Solicitation-RFI-Reopen_ver2.pdf

26 See: Deutsche Bank and Living Cities. "Recognizing the Benefits of Energy Efficiency in Multi-Family Underwriting." (2011) https://www.db.com/usa/img/DBLC_Recognizing_the_Benefits_of_Energy_Efficiency_01_12.pdf; Robbins, Lindsay, and Betsy Parrington. (2014) "Realizing Measurable Savings in Multifamily Buildings: Results from NYSERDA's Multifamily Performance Program"; Local Initiatives Support Corporation. (2013) "Green Retrofit Initiative Summary Evaluation Report"; Bright Power, ed. Stewards of Affordable Housing for the Future (SAHF). (2014).Energy and Water Savings in Multifamily Retrofits. Retrieved from: http://www.sahfnet.org/mfretrofitreport.html

27 Pratt Center for Community Development. (2012). Retrofit Standardization Initiative: Pratt Center is working to dramatically expand the residential energy efficiency market through an innovative study of standardize retrofits. Retrieved from http://prattcenter.net/projects/energy-efficiency/retrofit-standardization-initiative

bibliography

Data Sources

NYC Department of Buildings. LL87 2014 Compliance List Dataset.

NYC Department of City Planning. Primary Land Use Tax Lot Output (PLUTO) data file (14v1).

NYU Furman Center. Subsidized Housing Information Project (SHIP) Database. Retrieved on Aug 2014 from: http://datasearch.furmancenter.org/

NYC Mayor's Office of Long-term Planning and Sustainability (OLTPS). Year 4 Benchmark 2013 Report Dataset.

United States Census Bureau; American Community Survey. *2010 American Community Survey 5-Year Estimates*. (2012).

Publications

Bobker, M. (2014). *Turning Energy Benchmarking Big Data into Actionable Information in NYC*.

Bright Power, ed. Stewards of Affordable Housing for the Future (SAHF). (2014). *Energy and Water Savings* *in Multifamily Retrofits*. Retrieved from: http://www.sahfnet.org/mfretrofitreport.html

Bright Power. (2014). *Using Local Law 84 Benchmarking Results: A Guide for Multifamily Buildings*. Print.

Center on Wisconsin Strategy. (2011). *Building Industry and Market (BRIM): Market Scan Executive Summary*. Retrieved from: http://be-exchange.org/media/09_BRIM.pdf

Citizens Housing and Planning Council. (2014). *All Green Buildings Great and Small*. Retrieved from: http://chpcny.org/assets/All-Green-Buildings-Great-and-Small.pdf

Environmental Defense Fund (EDF). (2009). *The Bottom of the Barrel: How the Dirtiest Heating Oil Pollutes our Air and Harms our Health*. Retrieved from: http://www.edf.org/sites/default/files/10086_EDF_BottomBarrel_Exec_Summ.pdf

Fannie Mae. (2014). *Transforming Multifamily Housing: Fannie Mae's Green Initiative and Energy Star for Multifamily*. Retrieved from: https://www.fanniemae.com/content/fact_sheet/energy-star-for-multifamily.pdf

Furman Center at New York University. (2015). *Low Income Housing Tax Credit*. Retrieved from: http://furmancenter.org/institute/directory/entry/low-income-housing-tax-credit

Furman Center at New York University and the Institute for Affordable Housing Policy. (2011). *State of New York City Subsidized Housing 2011*. Retrieved from: http://furmancenter.org/files/publications/SHIPReportFinal.pdf

Furman Center at New York University and the Institute for Affordable Housing Policy. (2013). *State of New York City's Housing and Neighborhoods in 2013*. Retrieved from: http://furmancenter.org/files/sotc/SOC2013_HighRes.pdf

Global Energy Partners. (2010). *Energy Efficiency Potential Study for Con Edison Company of New York*.

Johnson, K. & Mackers E. (2013). *Scaling up Multifamily Energy Efficiency Programs: A Metropolitan Area Assessment. American Council for an Energy Efficient Economy*.

Metropolitan Council on Housing. (2014). *New York City's Affordable Housing Programs*. Retrieved from http://metcouncilonhousing.org/help_and_answers/nyc_affordable_housing_programs

National Resources Defense Council (NRDC). (2014). *Affordable Multifamily Housing Efficiency Project*. Retrieved from: http://www.neep.org/sites/default/files/resources/multifamily-housing-energy-efficiency-FS.pdf

Navarro, M. (Aug 11 2014). *Public Housing in New York Reaches a Fiscal Crisis*. The New York Times. Retrieved from: http://nyti.ms/1q5K1KE

New York City, Department of Housing Preservation and Development. (2015). *Select initial findings of the 2014 NYC Housing and Vacancy Survey*. Retrieved from: http://www1.nyc.gov/assets/hpd/downloads/pdf/2014-HVS-initial-Findings.pdf

New York City, Department of Housing Preservation and Development. (2013). *Housing New York City 2011*. Retrieved from: https://www.yumpu.com/en/document/view/34531039/hvs-report-2011

New York City Office of the Mayor & Glen, A. (2014). *Housing New York: A Five Borough, Ten Year Plan*. Retrieved from: http://www.nyc.gov/html/housing/assets/downloads/pdf/housing_plan.pdf

New York City Office of the Mayor. (9 Apr. 2015). Mayor De Blasio and HUD Secretary Castro Announce Nation's Largest Energy Savings Program for a Public Housing Authority. Retrieved from http://www1.nyc.gov/office-of-the-mayor/news/230-15/mayor-de-blasio-hud-secretary-castro-nation-s-largest-energy-savings-program-a#/0

New York City Mayor's Office of Long Term Planning and Sustainability (OLTPS). (2012). *New York City Local Law 84 Benchmarking Report*. Retrieved from: http://www.nyc.gov/html/gbee/downloads/pdf/nyc_ll84_benchmarking_report_2012.pdf

OLTPS. (2013). *Handbook for Co-ops and Condos*. Retrieved from: http://www.nyc.gov/html/gbee/downloads/pdf/handbook_for_co-ops_and_condos.pdf

OLTPS. (2013). *New York City Local Law 84 Benchmarking Report – Year 2*. Retrieved from: http://www.nyc.gov/html/planyc/downloads/pdf/publications/ll84_year_two_report.pdf

OLTPS. (2014). *New York City Local Law 84 Benchmarking Report – Year 3*. Retrieved from: http://www.nyc.gov/html/planyc/downloads/pdf/publications/2014_nyc_ll84_benchmarking_report.pdf

OLTPS. (2014). *One City, Built to Last*. Retrieved from: http://www.nyc.gov/html/builttolast/assets/downloads/pdf/OneCity.pdf

OLTPS. (2014). *Inventory of New York City Greenhouse Gas Emissions*. Retrieved from: http://www.nyc.gov/html/planyc/downloads/pdf/NYC_GHG_Inventory_2014.pdf

Pivo, G. (2012). *Energy Efficiency and its Relationship to Household Income in Multifamily Rental Housing*. Retrieved from: https://www.fanniemae.com/content/fact_sheet/energy-efficiency-rental-housing.pdf

Steven Winter Associates and New York City Energy Efficiency Corporation (NYCEEC). (2013). *Energy Savings Potential Calculator for New York City Multifamily Buildings*. Retrieved from: http://www.be-exchange.org/media/08_ESP_Tool.pdf

Steven Winter Associates and HR&A Advisors. (2012). *Recognizing the Benefits of Energy Efficiency in Multifamily Underwriting. For Deutsche Bank and Living Cities*. Retriever from: https://www.db.com/usa/img/DBLC_Recognizing_the_Benefits_of_Energy_Efficiency_01_12.pdf

Zuluaga, M. (2003). *Multifamily Benchmark*. Home Energy. www.homeenergy.org

about this report

Co-Authors

Richard Yancey
Building Energy Exchange

Ellen Abramowitz
Building Energy Exchange

Adam Hinge
Sustainable Energy Partnerships

Jeffrey Perlman
Bright Power

Conor Laver
Bright Power

Yetsuh Frank
Building Energy Exchange

Report Sponsors

ENERGY EFFICIENCY FOR ALL

nationalgrid

Steering Committee

Steve Caputo
Senior Advisor to the Deputy Mayor for Housing and Economic Development

Ashok Gupta
Senior Energy Economist, Natural Resources Defense Council

Advisory Group

Rory Christian
Director of New York Clean Energy, Environmental Defense Fund

Michael Colgrove
Director of Energy Programs, New York State Energy Research Development Authority

Candace Damon
Vice Chairman, HR&A Advisors

Aurelio M. DeYoanna
Manager of Vendor & Alliance Strategy in the Customer Strategy & Environmental Department, National Grid

Christopher Diamond
Director of Engineering and Technical Analysis, New York City Energy Efficiency Corporation

Chris Haun
Acting Director, New York City Housing Authority

David Hepinstall
Executive Director, Association for Energy Affordability

Cary Hirschstein
Partner, HR&A Advisors

Bomee Jung
New York Deputy Director, Enterprise Community Partners

Lloyd Kass
Director of Energy Services Marketing, New York Power Authority

John Lee
Deputy Director for Green Building and Energy Efficiency, New York City Mayor's Office of Sustainability

Richard Leigh
Director of Research, Urban Green Council

Phillip Madnick
Assistant Manager of the Multi-Family Energy Efficiency Program, Consolidated Edison

Christopher Mahase
Director of Sustainability, Housing Preservation and Development

Louis Rizzo
Lead Manager of Energy Efficiency Heating Programs, National Grid

Raya Salter
Senior Attorney, Energy and Equality, Natural Resources Defense Council

Jenna Tatum
Senior Policy Advisor, New York City Mayor's Office of Sustainability

Marc Zuluaga
Vice President and Director or Multifamily Energy Service, Steven Winter Associates

Design
O.M.

Maps
Elisabetta Di Stefano

Copy Editing
Angela Riechers

Acknowledgements
The authors gratefully acknowledge the very useful input provided by: Cai Steger and NRDC, Mark DeYoanna and National Grid, the NYU Furman Center, Yitzchok Friedman at NYC DoITT, Chris Haun at NYCHA, and the Mayor's Office of Sustainability, including Aaron Lewis, Alexandra Levine, Stacy Lee, and especially John Lee and Jenna Tatum.

BEEx: the building energy exchange connects New York City real estate and design communities to energy and lighting efficiency solutions through exhibitions, education, technology demonstrations, and research. We identify opportunities, navigate barriers to adoption, broker relationships, and showcase best practices at our resource center in the Surrogate's Courthouse.

be-exchange.org