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

Novembers 2015

Additional Information

This is an abbreviated version of a full length report, which can be found on the report project page: http://be-exchange.org/resources/project/49

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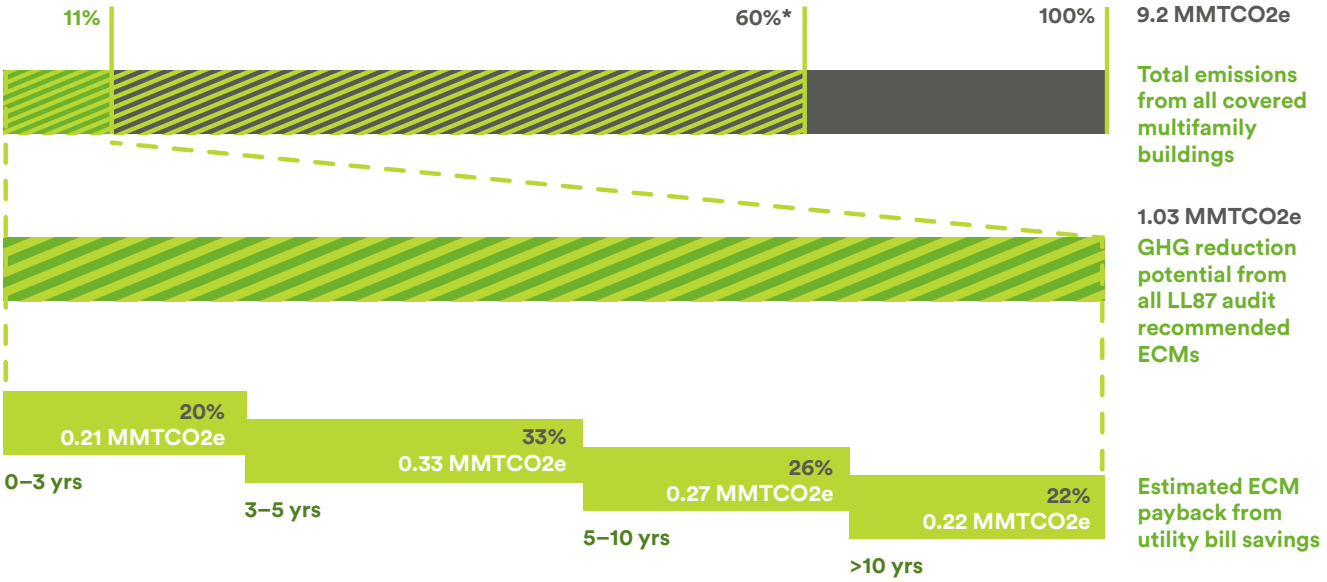
National Grid

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 in the top three segments have more than half of the total identified GHG reductions, while representing only 43% of the covered MF area, and only 40% of the total estimated retrofit costs
- Just two categories of energy conservation measures, Domestic Hot Water and Heating & Distribution, provide over 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 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

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 carbon by 60% in order to achieve 80 by 50 goals.

Photo: David McSpadden

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.**

Greener, Greater Buildings Plan

The groundwork for this evolution of the energy savings opportunities in New York City 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 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 Law (Local Law 87): Conducting an energy audit and retro-commissioning every ten years, beginning in 2013.

Lighting & Submetering Law (Local Law 88): Upgrading commercial lighting to meet current code, and sub-metering at large commercial tenants, by 2025.

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]

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,[2] and over 50% of the greenhouse gas emissions from buildings overall (as seen in Figure 4).[3] 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.[4] It is clear that large multifamily buildings must play a significant role in meeting the City's ambitious climate goals.

The implementation of the Greener, Greater Buildings Plan (see sidebar) 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 Energy Audit Law provide the basis of the analysis for this report.

Mayoral Initiatives: The Retrofit Accelerator

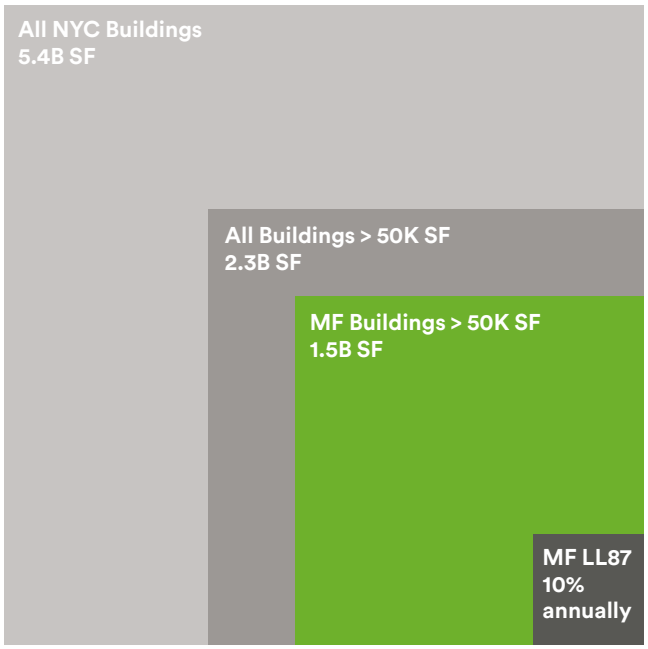
Energy efficiency retrofits in multifamily housing improve both the affordability and resiliency of NYC communities.

Several current initiatives, such as the City's Retrofit Accelerator put forth in Mayor de Blasio's climate action plan, *One City: Built to Last,* and the State's *Reforming the Energy Vision* plan, seek to bring energy efficiency retrofits to scale and realize a broad spectrum of sustainability and resiliency benefits. This will help put the City on a path to meet its goal of 80% carbon emissions reduction by 2050.

Figure 2: Area of NYC Building Stock by Use

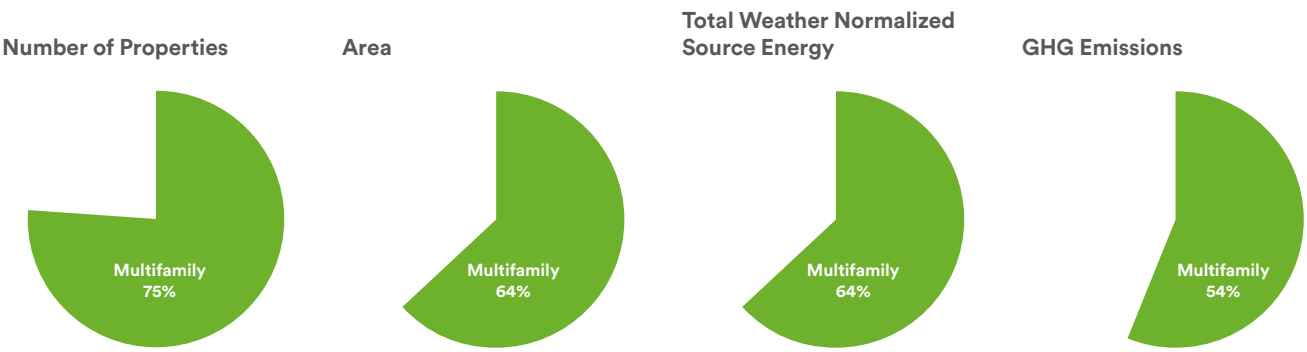
Residential buildings comprise the majority of New York City building area. This figure uses 2014 data from PLUTO and the City's Covered Buildings List.

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[5]



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)

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 applicable energy savings opportunities.

Benchmarking & Energy Audit Datasets

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.

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.[6] 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 and as designed.

Data Sources

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. Publicly available census and housing data informed the affordability assessments.

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. These characteristics are described at right. The "segments" were selected to capture not just properties that use energy differently but properties whose energy efficiency solutions would differ substantially.

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 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 current audit data. The City, in particular the Department of Buildings, 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.

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

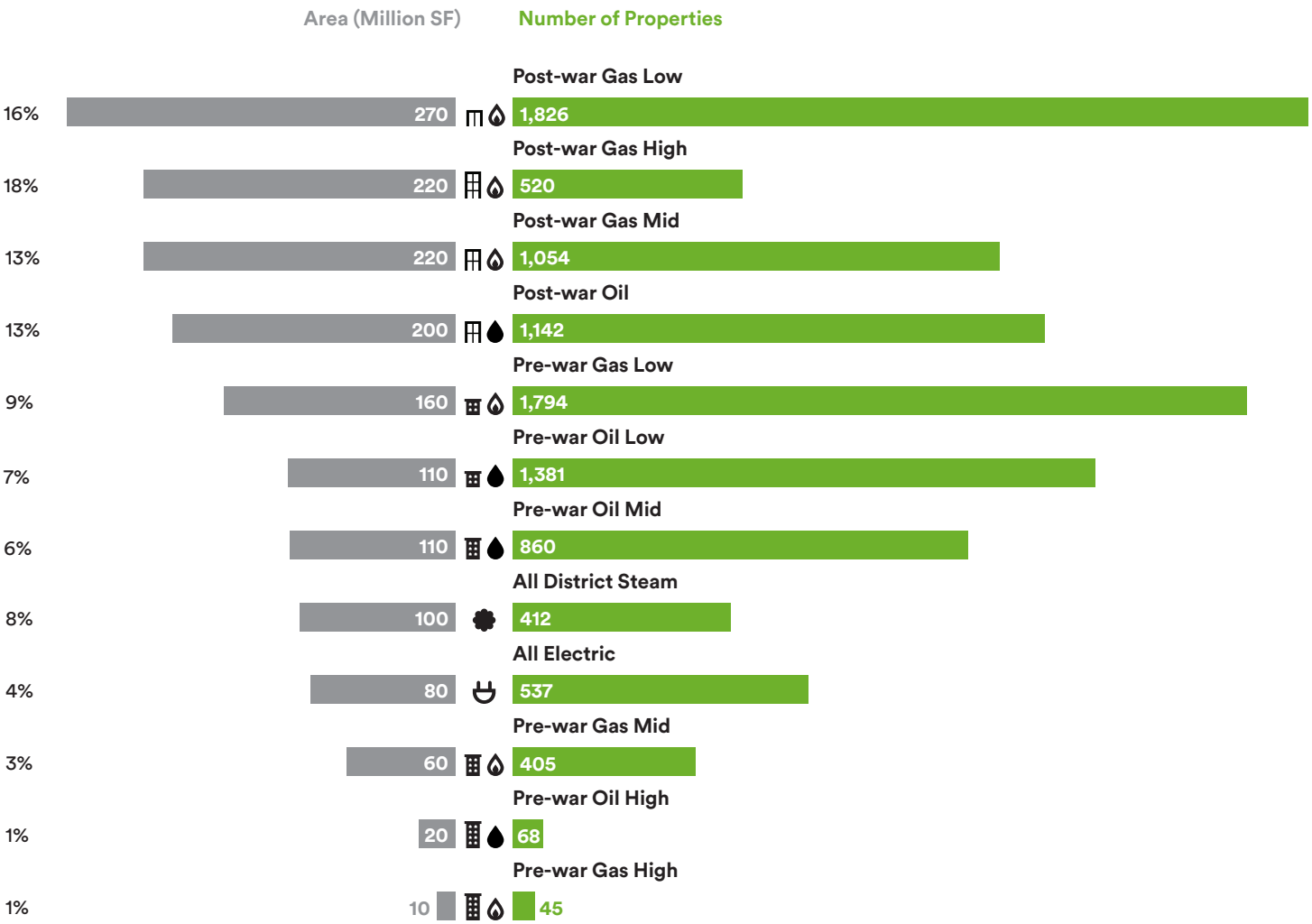
Oil
Includes all oil grades; cleaner and lighter #2 heating oil & heavier and dirtier #4 and #6 heating oils. All buildings using heavy oil (#6) must convert to cleaner fuels by 2016.

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

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%	30.8	16%	1.6	17%
Post-war Gas High	520	5%	220	14%	34.7	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%	25.7	13%	1.4	15%
Pre-war Gas Low	1,794	18%	160	10%	17.2	9%	0.8	9%
Pre-war Oil Low	1,381	14%	110	7%	13.4	7%	0.8	9%
Pre-war Oil Mid	860	9%	110	7%	12.3	6%	0.6	7%
All District Steam	412	4%	100	6%	14.8	8%	0.7	7%
All Electric	537	5%	80	5%	7.6	4%	0.2	2%
Pre-war Gas Mid	405	4%	60	4%	6.2	3%	0.3	3%
Pre-war Oil High	68	1%	20	1%	2.1	1%	0.1	1%
Pre-war Gas High	45	0%	10	1%	1.9	1%	0.1	1%
Total	10,043	100%	1,550	100%	192.7	100%	9.2	100%

Figure 6: Comparison of Number of Properties and Total Area 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 impacts of the segments.

opportunities

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.

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.

Post-war Gas Low, Post-War Oil, and Post-War Gas Mid properties have the greatest opportunity (54%) for energy savings in NYC, though they are only 44% of the area and 41% of the estimated retrofit costs. 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.

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 is a list of recommended energy conservation measures (ECMs). Auditors can submit ECMs to the City under 15 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 New York City multifamily buildings in each measure category, shown in Table 6. As seen in Table 6, Heating and Distribution measures and Domestic Hot Water measures have the greatest savings opportunity, payback within four years, and represent only 27% of the citywide cost of all ECMs.

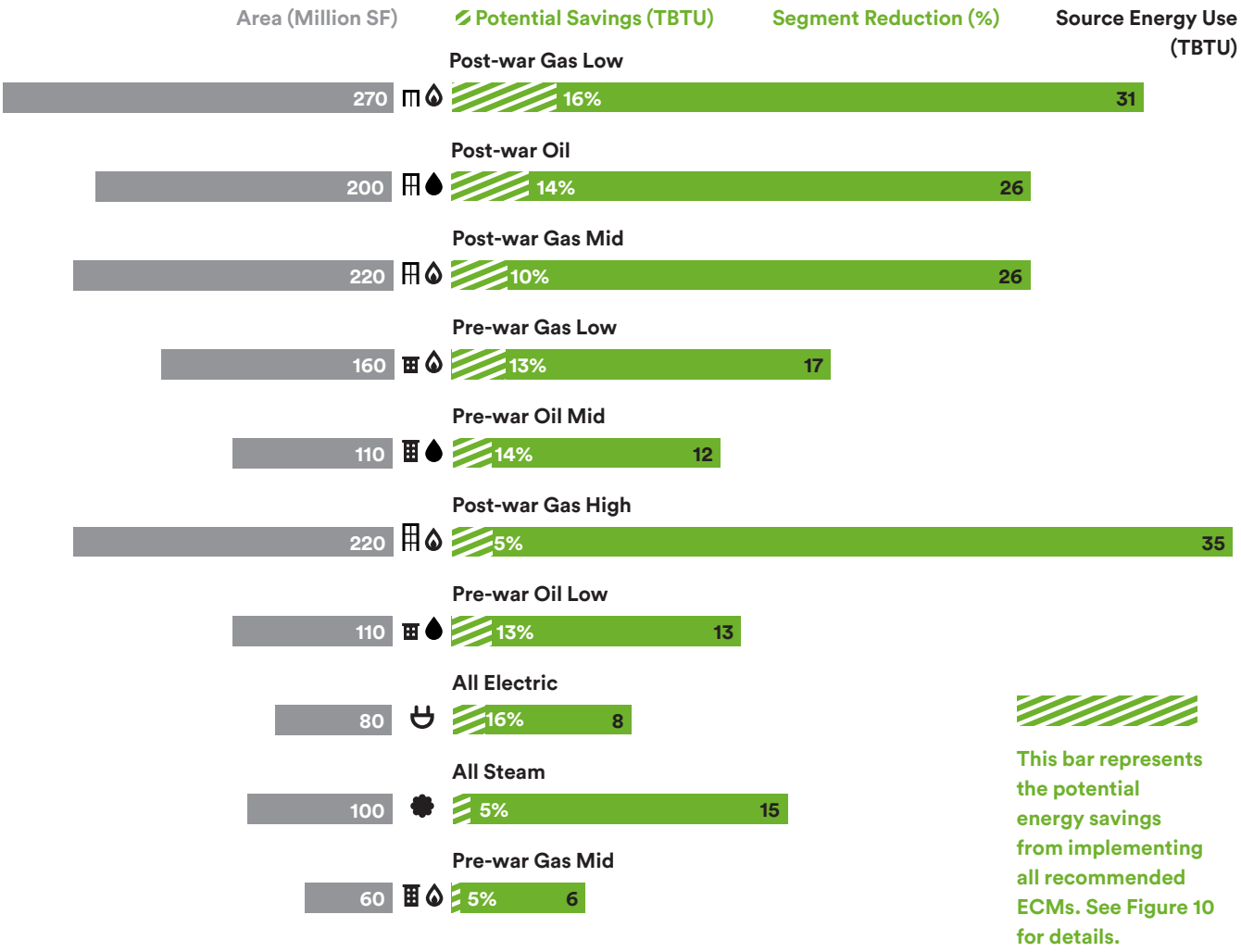
By combining ECM categories with segments, it is possible to see which types of ECMs have the biggest potential source energy savings on each property type. Figure 10 shows the savings impact of each ECM category for each segment. This chart can help guide property owners and city planners to

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%	$429	20%	4.8
Post-war Gas Mid	2.7	13%	0.13	13%	$223	10%	5.4
Pre-war Gas Low	2.3	11%	0.11	11%	$179	8%	7.7
Pre-war Oil Mid	1.7	8%	0.09	8%	$237	11%	4.8
Post-war Gas High	1.7	8%	0.07	7%	$41	2%	4.2
Pre-war Oil Low	1.7	8%	0.10	10%	$281	13%	5.0
All Electric	1.2	6%	0.03	3%	$496	23%	10.4
All District Steam	0.7	3%	0.03	3%	$53	2%	4.1
Pre-war Gas Mid	0.3	1%	0.01	1%	$14	1%	4.6
Total	20.9	100%	1.03	100%	$2,182	100%	5.9

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

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 report. 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 a 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.

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.

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. With additional data and verification, these can be developed into sensible retrofit "packages" for each segment.

Payback

Payback was also a key part of the analysis. According to the Energy Audit data, 53% of the potential source energy savings opportunity can be achieved through measures with payback of less than five years. Implementing these most frequently recommended measures would cost only 40% of estimated costs for implementing all measures.

Opportunities by Location

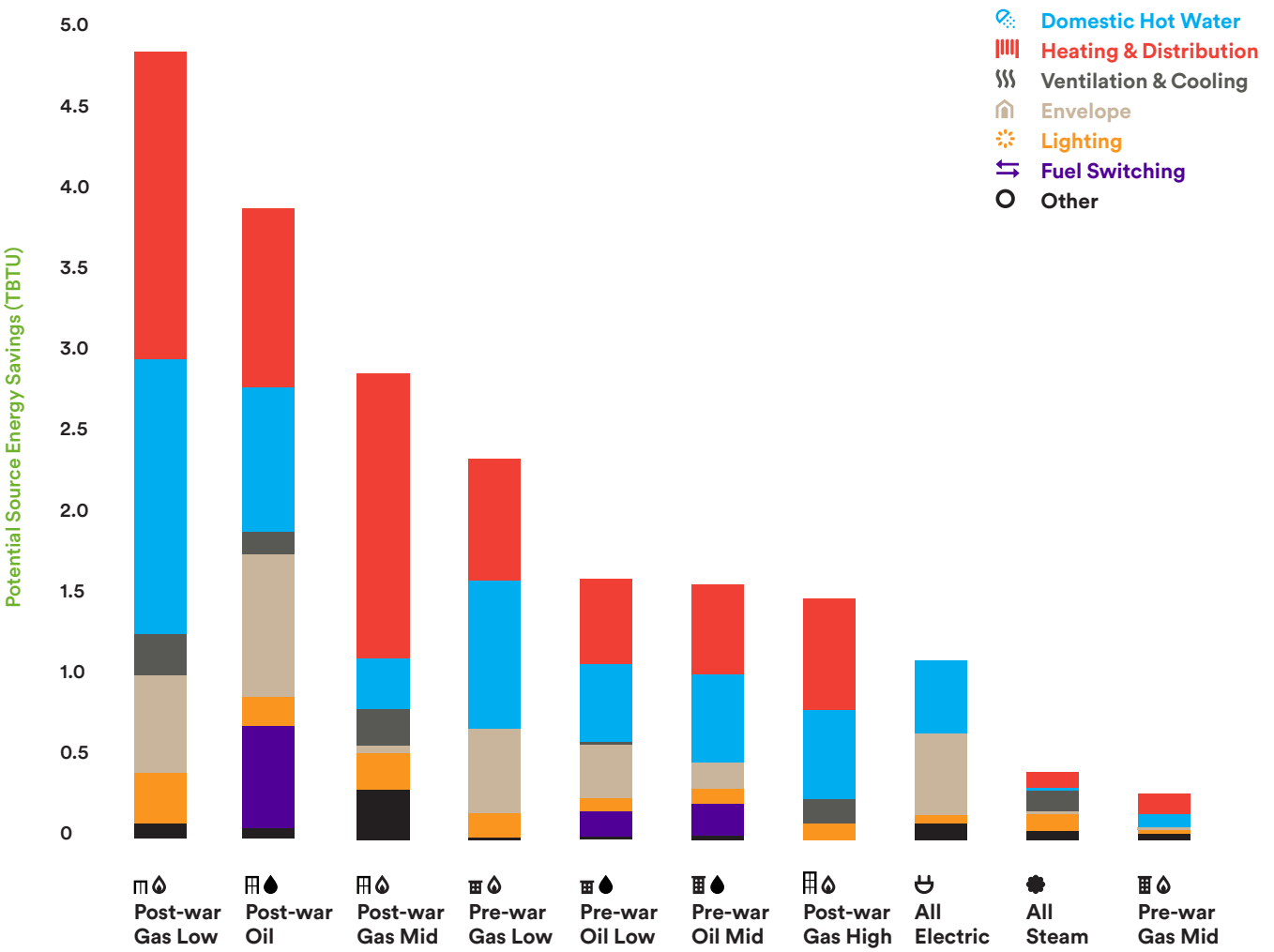
After determining the building typologies with the greatest potential energy savings and their recommended ECMs, it is critical to understand where these opportunities exist within the city. Mapping carbon reduction potential will be an important tool for New York City's Retrofit Accelerator and other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

Table 6: Potential Source Energy Savings by ECM Category

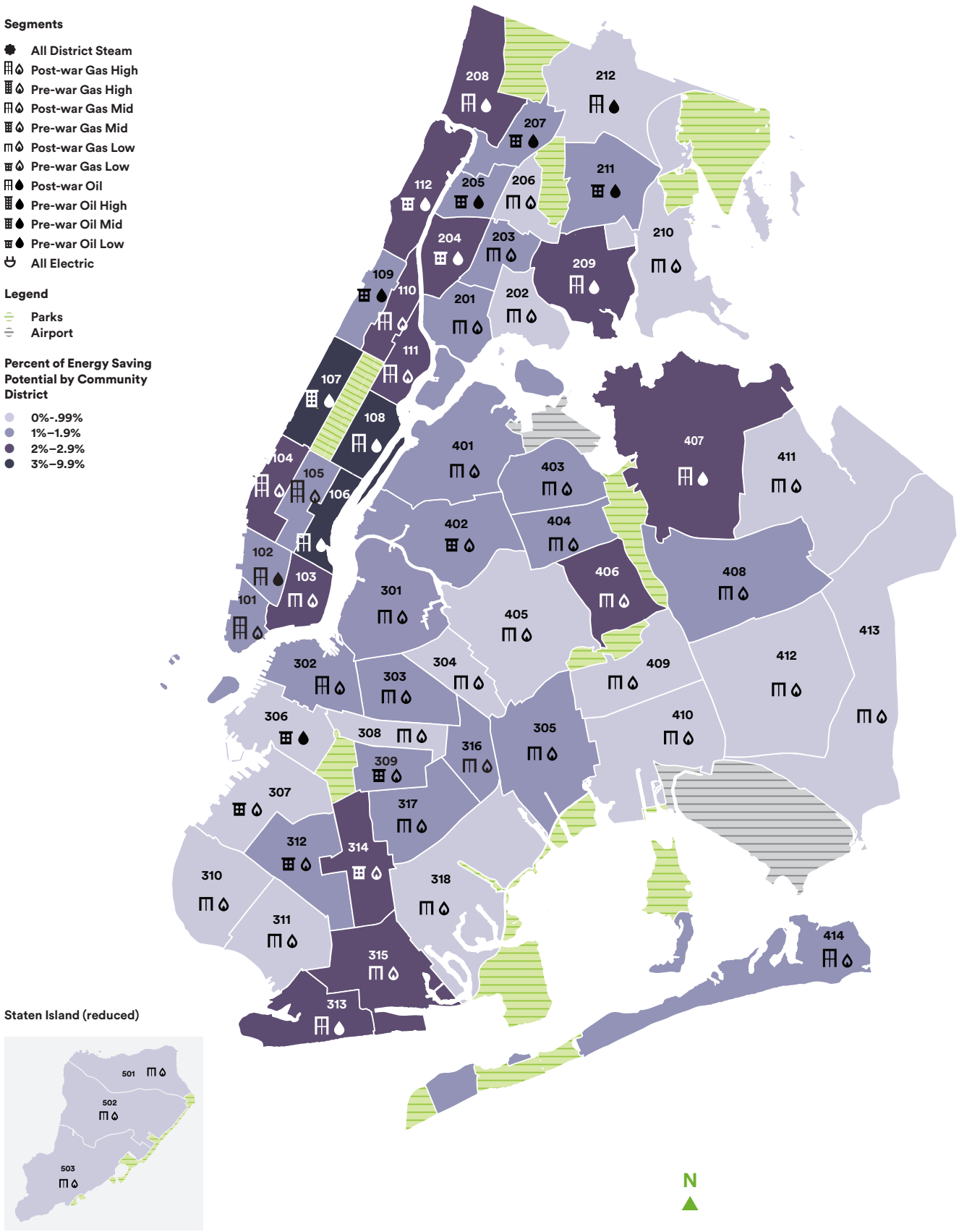
Category	Source Energy Potential Savings (TBTU)	Percent of Total Source Energy Potential Savings	GHG Potential Reduction (MMT-CO2e)	Percent of Total GHG Emissions Reduction Potential	Total Citywide Cost (Million $)	Percent of Citywide Cost	Payback (Years)
Heating & Distribution	7.9	38%	0.40	39%	$350	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%	$2180	100%	6

Figure 10: Potential 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. The potential source energy savings of each ECM category can be compared across each segment.

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



Map 1 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.

linkage to affordability

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.

Linking Segments to Affordable Housing Types

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. 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.

Map 6 identifies 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.

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.

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.

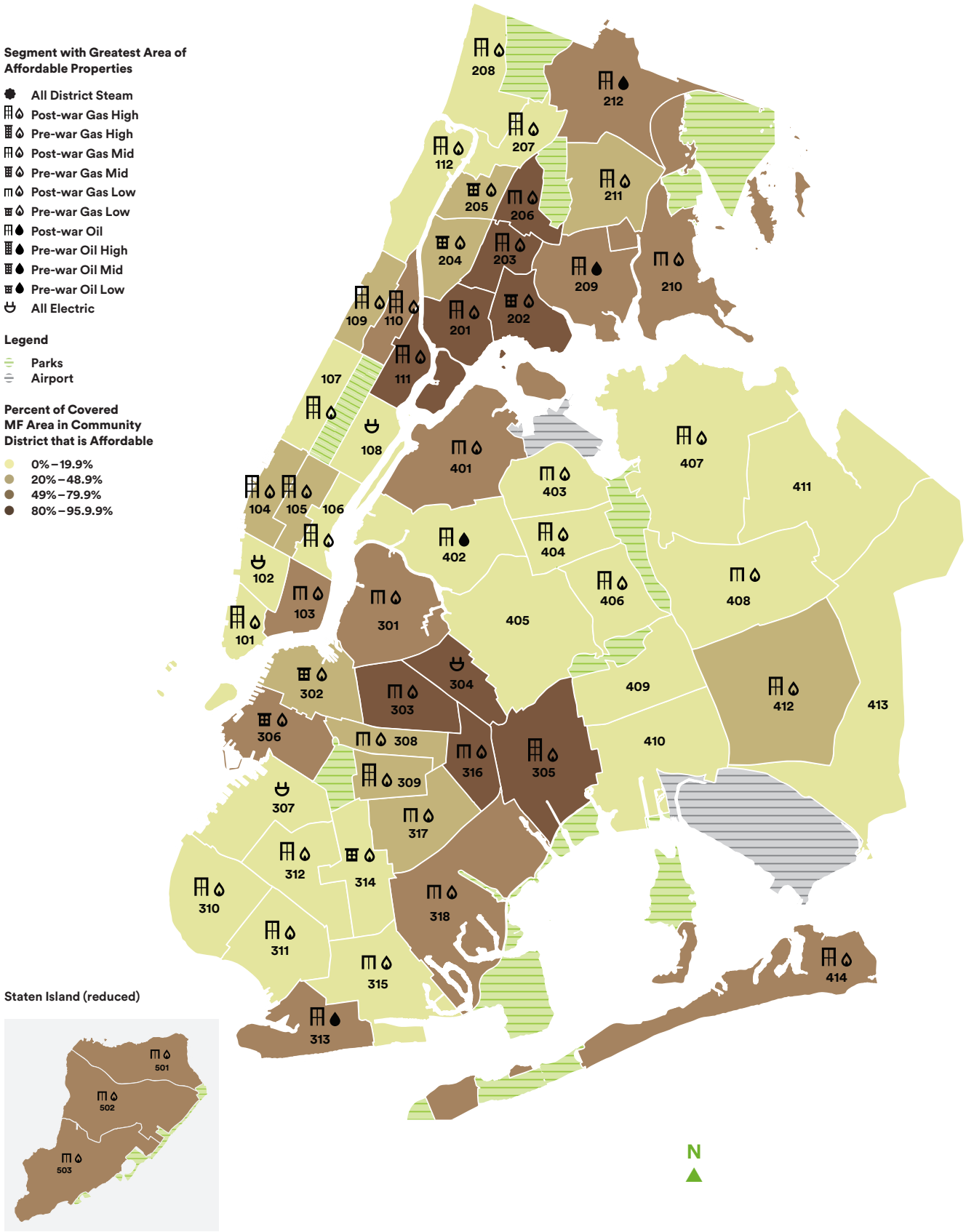
Outcome Uncertainty

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.

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.

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.

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.

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. This can be achieved through market research, improved data collection, comparative annual data analysis, and fuel switching.

Build the Potential - 2016-2018

The Retrofit Accelerator will bring data-driven, guided retrofits to multifamily buildings across the city. This program will provide New York City building owners with access to information, financing, and energy service providers in order to meet their retrofit goals. The Accelerator will also provide workforce development training to ensure that participants at all levels of the industry can contribute to the growing market.

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, through pilot projects, that the measures they recommend are effective and clearly document the actual return on investment of various energy conservation measures. In turn, these results can inform policies, codes, and incentive programs.

Make the Business Case - 2020+

Educated customers and highly skilled technical providers are required to develop a profitable energy efficiency retrofit market in New York City. Over the next few decades, the market must create a known framework for implementing energy efficiency measures that will mitigate the uncertainty and make such retrofits easy to implement.

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.

The findings 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. Processes should be developed to enable mid-course corrections and to 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 hints at the fact that there are even deeper savings to be found. Additionally, these findings 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.

This conversation should engage all of our communities, not just policy makers and technical experts. Although there are barriers to progress, addressing the role of our buildings in the climate crisis brings a host of 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.

endnotes

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

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

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

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

5 OLTPS. (2012). *New York City Local Law 84 Benchmarking Report*. 19

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disclaimer

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

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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
Director of Energy, 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

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