Equity and Affordability Impacts of Building Performance Standards: A Case Study of New York City’s Local Law 97

by

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B.S. Chemical Engineering
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Submitted to the Institute for Data, Systems, and Society in partial fulfillment of the requirements for the degree of

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Abstract

Building operations account for more than two-thirds of emissions in most U.S. cities. To reduce emissions from the building sector, cities and states are adopting Building Performance Standards. These laws require large buildings to comply with increasingly stringent emissions or energy limits, or otherwise pay a fine. Building Performance Standards are powerful decarbonization tools, but may inadvertently over-burden and increase the risk of displacement for low-income households. The risk is particularly acute in unsubsidized affordable housing, also known as naturally occurring affordable housing, where building owners can pass the costs of compliance or non-compliance on to tenants. In this thesis, I quantitatively and qualitatively examine the impact of New York City’s Building Performance Standard – Local Law 97 – on multifamily buildings. I find affordable housing buildings are less energy efficient than market rate buildings and that non-compliance penalties, retrofit costs, and increased energy costs from electrification may substantially increase housing costs for tenants who are already severely rent burdened and energy burdened. To prevent low-income households from shouldering these costs and to ensure they benefit from the other results of building decarbonization – such as health improvement and job creation – cities and states should provide financial and technical assistance, protect tenants, and incorporate flexibility for affordable housing owners to comply with Building Performance Standards.

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With this, I conclude my six years at MIT, a place I will always consider home. I am forever grateful for all of my friends, peers, staff, and professors who helped me learn and grow both inside and outside of the classroom. I am so proud of the person I have become and am ready and excited to embark on my next journey.
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Introduction

Cities and states across the United States are responding to the climate crisis with policies and plans to mitigate their climate impacts. In many large cities, buildings account for more than two-thirds of total emissions.\(^1\)\(^2\)\(^3\)\(^4\) Cities employ a host of policies aimed at reducing emissions in the building sector, from stronger building codes to financial incentives.\(^5\) In recent years, a new type of policy has emerged: Building Performance Standards (BPS). The National BPS Coalition\(^6\) defines BPS as “state and local laws that require existing buildings to achieve minimum levels of energy or climate performance.”\(^7\) As of 2022, 14 cities and states adopted a BPS and more than 20 cities and states were considering or developing a BPS.\(^8\)

Building Performance Standards differ across jurisdictions. Some are based on energy use intensity (EUI) while others establish emissions intensity limits. EUI is the amount of energy used per square foot, measured in kBtu/sqft/year, and emissions intensity is the carbon emissions from site energy use per square foot, measured in kgCO\(_2\)/sqft/year. Most BPS apply to both commercial and residential buildings but have vastly different compliance options, non-compliance consequences, and exemption criteria. For example, Boston’s BPS – the Building Emissions Reduction and Disclosure Ordinance (BERDO) – requires commercial and residential buildings larger than 35,000 square feet to meet emissions limits starting in 2025 or pay an alternate compliance payment of $234 per ton of carbon dioxide equivalent (tCO\(_2\)e) over the limit.\(^9\) New York City’s BPS – Local Law 97 – comes into effect in 2024, has an alternative compliance payment of $268/tCO\(_2\)e, authorizes certain carbon offsets and renewable energy credits (RECs) to support compliance, and applies to buildings over 25,000 square feet but largely exempts subsidized housing and some rent regulated housing.\(^10\) Washington D.C.’s

\(^{6}\) The National BPS Coalition is “a nation-wide group of state and local governments that have committed to inclusively design and implement equitable building performance standards and complementary programs and policies, working to advance legislation and/or regulation, with a goal of adoption by Earth Day, 2024.”
BPS – Building Energy Performance Standards (BEPS) – covers commercial and residential buildings larger than 50,000 square feet beginning in 2025 and 10,000 square feet beginning in 2030, requires EUI reductions rather than emission reductions, and has a non-compliance penalty of up to $10 per square foot.\textsuperscript{11} The U.S. Department of Energy summarizes the key components of these and other existing BPS.\textsuperscript{12}

BPS require building owners to take substantial action to reduce the climate impacts of their buildings or face material consequences. Theoretically, it is clear what building owners need to do. Building envelope improvements, HVAC system replacements, and lighting and appliance upgrades can significantly reduce a building’s EUI. As electricity from the grid becomes less carbon-intensive through deployment of utility-scale renewable energy sources, switching from fossil fuel systems to electric systems, such as heat pumps and induction stoves, can significantly reduce a building’s emissions intensity.\textsuperscript{13}

The reality is far more complicated, especially for multifamily buildings. Within the category of multifamily buildings, owner-occupied buildings and rental properties face different circumstances and challenges. Owner-occupied multifamily buildings are mostly cooperatives or condominiums, which typically have coordination challenges and cost sharing concerns.

In most cities, the majority of apartment buildings that BPS cover are rental properties. In New York City, about 70\% of apartments are renter-occupied.\textsuperscript{14} Rental apartments also face a coordination issue, often referred to as the “landlord-tenant split incentive problem.” The problem arises when the tenant pays the utility bills, but the landlord controls decisions that affect the building’s energy efficiency. In this situation, landlords do not benefit from energy savings measures, which led to decades of underinvestment in energy efficiency.\textsuperscript{15,16,17} A BPS shifts the incentives: landlords must invest in energy efficiency and other actions to avoid noncompliance costs. Tenants who pay the utility bills benefit from these investments in the

\begin{footnotes}
\footnote{12 “Building Performance Standards | Building Energy Codes Program.”}
\footnote{14 “2021 New York City Housing and Vacancy Survey Selected Initial Findings,” May 16, 2022, https://www.nyc.gov/assets/hpd/downloads/pdfs/services/2021-nychvs-selected-initial-findings.pdf.}
\footnote{16 Don Hynek, Megan Levy, and Barbara Smith, “‘Follow the Money’: Overcoming the Split Incentive for Effective Energy Efficiency Program Design in Multi-Family Buildings,” August 12, 2012.}
\end{footnotes}
form of lower bills. Moreover, building owners are responsible for complying with the BPS, but do not control the energy use of their tenants.¹⁸

A key concern with a BPS is the ability of landlords to pass retrofit costs or non-compliance penalties to their tenants through rent increases.¹⁹ If these costs outweigh the energy savings, tenants would end up paying higher housing and energy costs. In the absence of regulation that prevents large rent increases or cost pass-throughs, BPS could increase the risk of displacement, especially for low- and moderate-income tenants. Displacement is already an acute risk, as more than 19 million renter households across the United States are rent burdened, meaning they spend more than 30% of their income on housing costs.²⁰ In New York City, the median renter is cost burdened in three of the five boroughs.²¹

Energy costs make up a substantial portion of housing costs, especially in low-income households. The national median energy burden – the percentage of income spent on energy – for low-income households²² is approximately eight percent.²³ The two key determinants of energy burden, income and energy use, compound and amplify one another. Low-income renters can only afford to live in low-rent apartments. Low-rent and subsidized apartments tend to be older, draftier, and use outdated, inefficient equipment and appliances, increasing EUI.²⁴,²⁵,²⁶ Higher EUI results in higher energy costs and higher energy burden, even when controlling for apartment size.

High energy bills may induce financial stress for households, especially low-income renters and families with children.²⁷ After housing, the majority of a household’s expenditures go towards food, energy bills, and health-related costs. If a household does not have enough income for all

²¹ Bureau.
²² Low-income here is defined as less than or equal to 200% of the Federal Poverty Level
three, they may have to forego one or more of these necessities. This is the “Heat, Treat, or Eat Dilemma.”

High energy costs may force households to reduce or neglect heating and cooling or use unsafe or inadequate heat sources, leading to health risks, especially for children, older adults, and people with chronic health conditions. New or worsening health conditions lead to higher medical care and medication costs, further reducing the household’s ability to afford energy and food. Foregoing energy and food will worsen health conditions, and the vicious cycle continues. Eventually, the Heat, Treat, or Eat Dilemma could lead to debt, eviction, job loss, and other devastating consequences.

Due to decades of racist housing, economic, and planning policies, African-American and Hispanic households face disproportionately high energy burdens. Across the United States, African-American families are more likely to be renters and live in older homes with higher EUIs than white families. As a result, the median energy burden of African-American households is 43% higher than that of white households.

BPS should be grounded in the reality that low-income renters, who are disproportionately people of color, live in homes with higher energy use and emissions per square foot. If BPS are applied in the same way across all income and affordability bands, they will disproportionately burden low-income, non-white renters. At the same time, residents of these older, less-efficient buildings can benefit the most from lower energy bills and improved air quality and living conditions.

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30 Snyder, “Affordable Home Energy and Health: Making the Connections.”
33 Caswell, “Win-Win-Win? Evaluating the Climate, Health, and Equity Benefits of Retrofitting Low Income Housing in the US.”
37 Drehobl, Ross, and Ayala, “An Assessment of National and Metropolitan Energy Burden across the United States.”
Policymakers must wrestle with this benefit-burden dynamic when designing a BPS. To evaluate these tradeoffs, cities and states first need to understand the state and characteristics of the housing stock. They may then project the impact of various BPS designs and identify vulnerabilities and predict unintended consequences, such as displacement risks and disproportionate burden distribution. These steps should be done both at a macro-level through data analysis and also through community engagement and qualitative research methods. Together, these analyses will enable cities to design equity into BPS.

Here I analyze New York City’s multifamily housing stock and BPS (Local Law 97) as a case study, but the findings are relevant to other jurisdictions that design and implement BPS. I characterize the existing housing stock, project the impacts of Local Law 97 under several retrofit scenarios, and discuss multiple considerations and recommendations for BPS design. Ultimately, I seek to understand and expand upon existing methodologies to help jurisdictions maximize equity in conjunction with rapid decarbonization.

40 “Understanding the Housing Affordability Risk Posed by Building Performance Policies - IMT.”
Data and Methods

To analyze the impacts of Local Law 97 on affordable housing I proceed in three parts: (1) characterizing the current state of energy, emissions, and building types today, (2) assessing the impacts of Local Law 97 in the absence of energy efficiency improvements and fuel switching, and (3) exploring building retrofit scenarios and tradeoffs.

Current Status of Energy, Emissions, and Housing Types

Energy and Emissions Data

New York City publishes annual energy consumption and emissions data for privately owned buildings over 25,000 square feet through the NYC Open Data platform. New York City’s Benchmarking Law – Local Law 84 – requires building owners to report this data each year. The data include information about the building including primary property type, age, size, and unit density, along with energy usage and emissions data, such as site energy use intensity (EUI), energy consumption by fuel type, and emissions intensity.

I used the Local Law 84 data from 2017-2019 to establish the baseline energy use and emissions intensities for multifamily buildings larger than 25,000 square feet in New York City. I selected these years to avoid the impacts of COVID-19 in 2020-2021, when residential energy consumption increased substantially. I addressed inconsistencies and missing data per the procedures described in Appendix A. The final data set covers 8,873 multifamily buildings.

Housing Characterization

The benchmarking data do not include information about affordability of the building in terms of rent or occupant income. Below I describe four housing types – Subsidized, Naturally Occurring Affordable Housing, Rent Regulated, and Market Rate – and the data I used to classify each building.

The first two categories – Subsidized and Naturally Occurring Affordable Housing – together make up the broad category of affordable housing. Subsidized Housing is largely comprised of publicly owned housing, low-income housing tax credit (LIHTC) properties, and properties accepting Section 8 Housing Choice Vouchers. Naturally Occurring Affordable Housing (NOAH) – also referred to as Unsubsidized Housing – captures the stock of housing that is affordable.

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43 “Understanding the Housing Affordability Risk Posed by Building Performance Policies - IMT.”
affordable, often due to the building’s age and condition. Affordability is difficult to accurately define, but the Department of Housing and Urban Development (HUD) defines it as paying less than 30% of gross income on housing costs.

I separated the two types of affordable housing for several key reasons. Most subsidized Housing is exempt from complying with Local Law 97’s declining emissions limits and instead must follow a prescriptive pathway, which specifies energy conservation measures building owners must implement and is less stringent than the Local Law 97 emissions standards. NOAH are not exempt. Furthermore, while the affordability of Subsidized Housing is protected through regulations, NOAH are at risk of becoming unaffordable per the definition above. NOAH can become unaffordable if rents rise sufficiently due to market conditions or increased costs arising from certain types of renovation.

Subsidized Housing

The NYU Furman Center publishes property-level subsidy data. I matched the subsidy data to the benchmarking data via the Borough-Block-Lot (BBL) identification number and labeled properties that appeared in both the benchmarking and subsidized housing datasets as “Subsidized.” 1,757 buildings in the baseline data (20%) are subsidized.

Naturally Occurring Affordable Housing

The definition of NOAH is less clear and no known data sets identify and track NOAH. I assess affordability through the Fair Market Rent (FMR) metric as defined and calculated by HUD. FMR is “the 40th percentile of gross rents for typical, non-substandard rental units occupied by

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47 Schreiber, “Proactive Preservation of Unsubsidized Affordable Housing in Emerging Markets: Lessons from Atlanta, Cleveland, and Philadelphia.”
49 All buildings in New York City have a unique BBL, which is typically included in datasets and allows for cross-referencing and combining data.
recent movers in a local housing market.”\textsuperscript{50} HUD calculates FMR by number of bedrooms for the New York, New York metropolitan area each year. Table 1 reports the FMR for New York City in 2019.\textsuperscript{51}

Table 1. FY 2019 Monthly Fair Market Rents for New York, New York Metro Area

<table>
<thead>
<tr>
<th>Number of Bedrooms</th>
<th>Fair Market Rent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency/Zero-Bedroom</td>
<td>$1,599</td>
</tr>
<tr>
<td>One-Bedroom</td>
<td>$1,599</td>
</tr>
<tr>
<td>Two-Bedroom</td>
<td>$1,831</td>
</tr>
<tr>
<td>Three-Bedroom</td>
<td>$2,324</td>
</tr>
<tr>
<td>Four-Bedroom</td>
<td>$2,475</td>
</tr>
</tbody>
</table>

Building-level rent data are not available, but the American Community Survey (ACS) publishes census tract-level median rent data by number of bedrooms.\textsuperscript{52} I was therefore able to categorize census tracts as NOAH or not NOAH and apply that label to all buildings in the census tract. I compared the 2019 ACS data to the FMR data and if the FMR exceeded the median rent in four of the five apartment sizes, I labeled the tract as NOAH. This resulted in 620 NOAH tracts out of 2,166 total (29%). Figure 1 shows New York City census tracts, with NOAH tracts shaded darker. I labeled the buildings in NOAH tracts as NOAH if they were not already identified as subsidized. This resulted in 2,175 NOAH buildings (25% of the total).


Figure 1. NOAH Census Tracts. Areas shaded in dark green are categorized as census tracts containing Naturally Occurring Affordable Housing

Rent Regulated Housing

New York City is one of the few jurisdictions in the country that has some form of rent regulation. I use the term rent regulation to include both rent-controlled and rent stabilized apartments. Rent regulated apartments are subject to regulations that protect tenants from rent increases.\(^5\) As of 2021, there were about 16,000 rent-controlled and just over one million rent stabilized apartments in New York City.\(^4\) Rent regulated apartments are not specifically restricted to low-income tenants, but overall are inhabited by larger percentages of Black and Hispanic tenants and tenants with incomes below the poverty line than non-regulated apartments.\(^5\)

\(^5\) “Profile of Rent-Stabilized Units and Tenants in New York City” (NYU Furman Center, June 2014), https://furmancenter.org/files/FurmanCenter_FactBrief_RentStabilization_June2014.pdf.
New York State’s Department of Homes and Community Renewal (HCR) publishes a list of buildings with rent regulated apartments for each of New York City’s five boroughs. Similar to the subsidized housing data, the rent regulated data contains the building’s BBL, through which I matched this data to the benchmarking data. I labeled buildings that appeared in the HCR data and were not already labeled subsidized or NOAH as Rent Regulated, which resulted in 2,827 buildings (32%) of the total.

A limitation of this data is the inability to identify what percentage of the building’s units are rent regulated. This is relevant due to how Local Law 97 treats buildings with more 35% or more rent regulated units, which I discuss in the Covered Buildings section below.

Market Rate Housing

Market rate housing captures a wide range of housing, but in this context is comprised of all buildings which are not subsidized, NOAH, or rent regulated. Table 2 summarizes the number of buildings in the baseline data in each housing category.

<table>
<thead>
<tr>
<th>Housing Category</th>
<th>Number of Buildings</th>
<th>Percent of Buildings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subsidized</td>
<td>1,757</td>
<td>20%</td>
</tr>
<tr>
<td>NOAH</td>
<td>2,175</td>
<td>25%</td>
</tr>
<tr>
<td>Rent Regulated</td>
<td>2,827</td>
<td>32%</td>
</tr>
<tr>
<td>Market Rate</td>
<td>2,114</td>
<td>24%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>8,873</td>
<td>100%</td>
</tr>
</tbody>
</table>

Building Characterization

Buildings differ widely by floor area, height, and age, which impact buildings’ operational efficiencies. For example, older buildings may have less insulation and old, inefficient appliances which both result in higher EUIs than newer buildings. Larger buildings may have a lower surface area to volume ratio, which results in less heat lost to the environment and thus lower EUIs for heating and cooling than smaller buildings. In general, EUI, emissions intensity, and retrofit solutions differ across building types. I categorized the buildings by size and age to understand the relationships among building characteristics and energy and emissions intensities. I defined three building size categories and three age categories, as shown in Table 3. The

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combination of the three size categories and three age categories results in nine building types. I labeled each building as one of these nine types and summarized the EUI and emissions intensity for each one.

I analyzed the baseline data to understand the relationships among building characteristics (age, size, unit density), housing type, and energy and emissions intensities. First, I categorized each building by its age and size based on the definitions in Table 3. I summarized the EUI and Emissions Intensity for all nine building categories.

Table 3. Building Size and Age Category Definitions

<table>
<thead>
<tr>
<th>Size Category</th>
<th>Definition</th>
<th>Age Category</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low-Rise</td>
<td>&lt;500,000 square feet + &lt;10 floors</td>
<td>Pre-War</td>
<td>Pre-1945</td>
</tr>
<tr>
<td>High-Rise</td>
<td>&lt;500,000 square feet + 10+ floors</td>
<td>Post-War</td>
<td>1946-1980</td>
</tr>
<tr>
<td>Very Large</td>
<td>&gt;500,000 square feet</td>
<td>Post-1980</td>
<td>1981-present</td>
</tr>
</tbody>
</table>

Finally, I performed Ordinary Least Square (OLS) regressions to describe the relationships between housing type and EUI and Emissions Intensity, controlling for building age, size, and unit density. I modeled the relationship as:

\[ \hat{Y}_t = \beta_0 + \beta_1X_{1t} + \beta_2X_{2t} + \cdots + \beta_kX_{kt} \]

Where:
- \( \hat{Y}_t \) is the dependent variable
- \( \beta_0 \) is a constant
- \( \beta_1, \beta_2, \ldots, \beta_k \) are estimates of the coefficients of the regressors
- \( X_{1t}, X_{2t}, \ldots, X_{kt} \) are the explanatory and control variables

**Local Law 97 Impacts**

Local Law 97 is codified in the New York City Administrative Code in §28-320. The law defines which buildings are covered, the emissions limits each covered building must comply with over time (Table 4), the penalties for non-compliance, and fuel emissions factors used to calculate building emissions.

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57 Definitions are based on a report on New York City buildings performed by Building Energy Exchange.
59 Chapter 3: Maintenance of Buildings.
Covered Buildings

Buildings that exceed 25,000 square feet, two or more buildings on the same tax lot that exceed 50,000 square feet, and condominiums governed by the same board that exceed 50,000 are generally covered by Local Law 97. However, there are exceptions for several types of multifamily buildings, including buildings owned or on land owned by the New York City Housing Authority (NYCHA), buildings that participate in project-based federal housing programs, and buildings in which more than 35% of units are rent regulated.

Due to these exceptions, most of the buildings in my data set labeled Subsidized and a portion of buildings labeled Rent Regulated are not legally required to meet the emissions limits set forth in §28-320 and instead must comply with a set of prescriptive energy conservation measures as defined in §28-321.60 New York City publishes a list of covered buildings, but it includes buildings covered under either Article 320 or 321.61 Thus, in my analysis I treat all buildings in the data set as if they must comply with the emissions limits or otherwise pay a penalty. The results therefore overestimate the penalties that Subsidized and Rent Regulated buildings will be subject to in New York City. However, these results can illustrate the impacts of BPS that do not exempt subsidized housing, such as those enacted in Boston and Washington, D.C.62,63 Moreover, NOAH buildings are unlikely to be exempt and for the reasons discussed above are the focus of my analysis.

Emissions Limits and Penalties

Local Law 97 establishes annual building emissions limits from 2024 through 2050. The limits for the first time period – 2024 through 2029 – were written into §28-320.3.1. Emissions limits beyond 2029 were established by a rule adopted by the Department of Buildings in January 2023.64 Table 4 shows the emissions limits for Multifamily Buildings.

---

60 Chapter 3: Maintenance of Buildings.
Table 4. Local Law 97 Emissions Limits for Multifamily Buildings

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Emissions Limit (kgCO₂e per sqft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2024-2029</td>
<td>6.750</td>
</tr>
<tr>
<td>2030-2034</td>
<td>3.347</td>
</tr>
<tr>
<td>2035-2039</td>
<td>2.692</td>
</tr>
<tr>
<td>2040-2049</td>
<td>2.053</td>
</tr>
<tr>
<td>2050+</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Buildings that exceed these emissions limits will have to pay a penalty equal to $268 per ton of carbon dioxide equivalent (CO₂e) over the limit.

I calculated the annual penalties per square foot for each building in the dataset as:

\[
AnnualPenalty_t = \text{penalty} \times \frac{(EmissionsIntensity_t - LL97limit_t)}{1000}
\]

Where:
- \( AnnualPenalty_t \) = total penalty incurred by the building in year \( t \)
- \( \text{penalty} \) = $268 per metric ton of CO₂e
- \( EmissionsIntensity_t \) = building emissions intensity in kgCO₂e per square foot in year \( t \)
- \( LL97limit_t \) = emissions limit in kgCO₂e per square foot in year \( t \)

I also calculated the annual penalties for the average apartment in each building and the entire building by dividing the equation above by the unit density (units per square foot) and multiplying the equation above by the total building area (square feet), respectively.

I calculated the emissions intensity for each building as:

\[
EmissionsIntensity_t = \sum_i EUI_{i,t} \times EF_i
\]

Where:
- \( EUI_{i,t} \) = energy use intensity of fuel type \( i \) in kBtu per square foot in year \( t \)
- \( EF_i \) = emissions factor of fuel type \( i \) in kgCO₂e per kBtu

The baseline data includes energy use for the following fuel types: Fuel Oil #1, Fuel Oil #2, Fuel Oil #4, Fuel Oil #5&6, Diesel #2, Kerosene, Propane, District Steam, District Hot Water, District Chilled Water, Natural Gas, and Electricity. For simplicity, I excluded fuel types that were used in less than 0.5% of buildings, so the final list of relevant fuel types is: Fuel Oil #2, Fuel Oil #4, Fuel Oil #5&6, District Steam, Natural Gas, and Electricity. Table 5 shows the emissions factors.
for each of these fuel types every five years. All values come directly from the statute or associated rules unless otherwise noted.

<table>
<thead>
<tr>
<th>Table 5. Fuel Emissions Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fuel Type</strong></td>
</tr>
<tr>
<td>-----------------</td>
</tr>
<tr>
<td>Fuel Oil #2</td>
</tr>
<tr>
<td>Fuel Oil #4</td>
</tr>
<tr>
<td>Fuel Oil #5&amp;6⁶⁵</td>
</tr>
<tr>
<td>District Steam</td>
</tr>
<tr>
<td>Natural Gas</td>
</tr>
<tr>
<td>Electricity</td>
</tr>
</tbody>
</table>

Penalty Burden

I define a new metric – “Penalty Burden” – to describe the relative impact of the Local Law 97 penalties on residents’ costs of living. I calculated the median Penalty Burden at the census tract level as:

\[
Penalty_{Burden_{tract}} = \frac{Median\ Penalty\ per\ Apartment_{tract}}{Median\ Rent_{tract}}
\]

I calculated the median Penalty per Apartment by tract by matching the BBL to the Census Tract via the street address. The United States Census Bureau has a “Geocoder” which matches addresses to census geographies.⁶⁸ I imported the tract-level median rent from the ACS 2019 survey.⁶⁹

Energy Costs

I calculate annual energy costs per square foot for each building as:

---

⁶⁵ The emissions factor for Fuel Oil #5&6 is not included in the statute or associated rules, so I used the value reported in the Energy Start Portfolio Manager Technical Reference Document (https://portfoliomanager.energystar.gov/pdf/reference/Emissions.pdf)

⁶⁶ The statute and associated rules only report emissions factors for District Steam for the first two time periods; I calculated the emissions factors for the remaining time periods by assuming a constant rate of emissions intensity reductions from the first two time periods.

⁶⁷ New York State’s Climate Leadership & Community Protection Act (CLCPA) requires New York’s electric grid to be 100% zero-emissions by 2040. The emissions factors are thus zero for 2040 and beyond. The 2035-2039 emissions factor is the average of the 2030-2034 and 2040-2045 emissions factor, which assumes a linear reduction to zero-emissions.


⁶⁹ ACS Code B25031_001E
\[ AnnualEnergyCosts_t = \sum_i EUI_{i,t} \times EP_{i,t} \]

Where:
\( EUI_{i,t} \) = energy use intensity of fuel type \( i \) in kBtu per square foot in year \( t \)
\( EP_{i,t} \) = energy price of fuel type \( i \) in dollars per kBtu in year \( t \)

Similar to the penalty calculation, I also calculated the energy costs for the average apartment in each building and the entire building.

Future energy prices are highly uncertain and will be impacted by complex macroeconomic and socioeconomic dynamics. Instead of projecting energy prices through 2050, I used three energy price scenarios: Low, Mid, and High. The Mid scenario assumes real energy prices remain at their 2022 levels through 2050, and the Low and High scenarios are 25\% lower and higher, respectively. Note that 2022 energy prices were higher than previous years due to the Russian invasion of Ukraine and the resulting disruption to energy supplies. If prices were to return to pre-war levels, they would fall by 5-10\% from the Mid-price scenario.

Table 6 shows the energy prices by fuel type for each scenario.
Table 6. Energy Prices by Fuel Type

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Units</th>
<th>Low</th>
<th>Mid</th>
<th>High</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel Oil #2</td>
<td>$/kBtu</td>
<td>$0.028</td>
<td>$0.037</td>
<td>$0.046</td>
<td>NYSERDA 71</td>
</tr>
<tr>
<td>Fuel Oil #4</td>
<td>$/kBtu</td>
<td>$0.028</td>
<td>$0.037</td>
<td>$0.046</td>
<td>NYSERDA 73</td>
</tr>
<tr>
<td>Fuel Oil #5&amp;6</td>
<td>$/kBtu</td>
<td>$0.028</td>
<td>$0.037</td>
<td>$0.046</td>
<td>NYSERDA 74</td>
</tr>
<tr>
<td>District Steam</td>
<td>$/kBtu</td>
<td>$0.021</td>
<td>$0.028</td>
<td>$0.035</td>
<td>SWA 76</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>$/therm</td>
<td>$1.442</td>
<td>$1.922</td>
<td>$2.403</td>
<td>NYSERDA 78</td>
</tr>
<tr>
<td>Electricity</td>
<td>$/kWh</td>
<td>$0.166</td>
<td>$0.221</td>
<td>$0.277</td>
<td>NYSERDA 80</td>
</tr>
</tbody>
</table>

**Building Retrofits**

Building owners and operators must choose between two options: do nothing, denoted Business-As-Usual (BAU), or retrofit their building. Under BAU I assume the building’s EUI and fuel type composition remain the same as the baseline through 2050. In the BAU scenario, most buildings will face penalties for exceeding the emissions limits.

To avoid penalties under LL97 building owners may choose to retrofit their buildings to be more energy efficient and/or electrify the building’s systems. Each building’s optimal retrofit pathway will be unique due to technical and financial constraints imposed by its size, configuration, age, and other attributes. To illustrate the range of retrofit possibilities, I modeled three different retrofit scenarios.

---

70 Average of weekly residential heating oil price in the New York City region in 2022
72 Average of residential heating oil prices in the New York City region for 2022
73 “Average Home Heating Oil Prices and Heating Fuel Prices Dashboard.”
74 Average of residential heating oil prices in the New York City region for 2022
75 “Average Home Heating Oil Prices and Heating Fuel Prices Dashboard.”
76 Based on costs used in case study on NYC steam system
77 “Clanging Pipes and Open Windows: Upgrading NYC Steam Systems for the 21st Century,” accessed March 7, 2023, https://assets.ctfassets.net/ntcn17ss1ow9/73gDFE9yMk45H4mEezo18y/f2532fe00d1ae79e1b68d5d6de4c7524/EEF A-Upgrading_NYC_Steam_Systems.pdf.
78 Average of monthly residential natural gas prices in New York State in 2022
80 Average of monthly residential electricity prices in New York State in 2022
Scenario 1: Gradual EUI Reductions

In Scenario 1, the EUI of all buildings falls by the exact amount required to meet the Local Law 97 limits. The percent reductions are the same across all fuel types and the reduction occurs in the year the emissions limits fall. Note LL97 requires zero emissions by 2050 whereas EUI cannot fall to zero. The result for 2050 thus represents the boundary of what energy efficiency alone can achieve.

Scenario 2: Fully Electric in 2024

All buildings are fully electrified in 2024, but the total EUI remains the same from the baseline through 2050. In other words, EUI remains constant but is entirely shifted from natural gas, fuel oil, and district steam to electricity.

Scenario 3: Fully Electric Passive House in 2024

All buildings are fully electrified and brought to the Passive House EUI standard of 38 kBtu/sqft/year. The retrofit occurs in 2024 and the total EUI remains constant through 2050. For most buildings, this scenario includes both an EUI reduction and a shift to electricity.

Figure 2 shows the EUI by fuel type over time for each scenario for a representative building. I selected a building from the most common building type category (pre-war, low-rise) with an average EUI (85.1) that uses a mix of fuels.

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Avoided Penalties and Energy Costs

For each scenario, I calculated the penalties incurred and the energy costs from 2024 through 2050 per the methods discussed above. I then subtracted the BAU penalties and energy costs from each scenario to calculate the avoided penalties and energy cost savings. To compare the retrofit scenarios to one another and to the BAU scenario I calculated the net present value (NPV) of these metrics. The NPV is sensitive to the discount rate, so I used a range of discount rates: 2%, 5%, and 8%/year. These discount rates represent a range of potential interest rates of loans for financing building retrofit costs. Due to the current inflationary market conditions and higher interest rates, building owners financing projects today will likely face nominal interest rates in the middle to high range (5-8%/year). As of April 2023, the New York City Energy Efficiency Corporation offers multifamily building owners 6.0-7.5%/year interest rates, but

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affordable housing owners and developers may be able to access lower interest rate loans. Discount rates also represent the level of risk and the value of the future. Building retrofits are relatively low-risk investments with likely positive benefits and savings, so a lower discount rate may be appropriate.

The resulting NPVs of avoided penalties and energy cost savings help identify the range of capital expenditures for which investments in building retrofits would be cost effective. Due to limited data about actual retrofit costs and energy savings, I qualitatively discuss this range and areas for further research.

Results

Building Type and Housing Characterization

Building Age and Size Categories

Figure 3 shows the breakdown of buildings in the data set by age and size, as defined in Table 3. Almost half of the multifamily buildings in the data set are pre-war low-rise – meaning they were built prior to 1945 and have fewer than 10 stories. About one quarter of buildings are high-rise, and building age is relatively evenly distributed across the three categories. The remaining quarter is largely comprised of post-war and post-1980 low-rise buildings. Very large buildings make up less than 2% of all buildings.

Figure 3 also shows the distribution of emissions across the building age and size categories. As expected, the low-rise buildings contribute only 49% of emissions despite making up 74% of the multifamily building stock. On the other hand, very large buildings contribute more than 12% of total CO₂ emissions. Very large buildings thus present opportunities for concentrated emissions reductions.
Figure 3. Distribution of number of buildings (left, light gray) and contributed CO2 emissions (right, dark gray) across building age and size categories in the baseline period (2017-2019).

**Fuel Types**

Natural gas is the dominant source of energy for buildings in New York City. As shown in Figure 4, natural gas makes up over 60% of the total site energy use of all buildings in the baseline period (2017-2019). Electricity makes up about 25%, and the remaining 15% of site energy use is provided by district steam and fuel oils. Few buildings have fully electrified heating systems, so the vast majority of the electricity is used for lighting, appliances, and air conditioning. Fuel oil, district steam, and much of the natural gas are only used for space and water heating. Smaller fractions of the natural gas are used for cooking and for whole-building or campus co-generation systems.

Figure 4. Total Site Energy Use by Fuel Type in the Baseline Period (2017-2019)
Figure 5 shows the energy use by fuel type for each building age and size category. Electricity makes up slightly larger portions of total energy in newer buildings, which aligns with the expectations that new buildings are more likely to have air conditioning and use electricity for heating and cooling. Fuel oil is much more prevalent in old buildings than new ones, which is a result of the shift to gas and city policies that prohibited the use of fuel oil 6 in 2015 and will phase out fuel oil 4 by 2030.85 Within each building age category, low-rise buildings rely most on natural gas, while district steam is used almost exclusively in high-rise and very large buildings.

Figure 5. Breakdown of Fuel Types across Building Age and Size Categories in the Baseline Period (2017-2019)

Housing Categories

I also categorized the buildings by housing affordability. As described above, 20% of buildings are Subsidized, 25% are NOAH, 32% are Rent Regulated, and 24% are Market Rate. However, these proportions differ across the age and size categories, as shown in Figure 6. More than half

of buildings built after 1980 are subsidized housing, which was a result of major efforts to combat the housing crisis in the 1980s, such as the creation of the NYC Department of Housing Preservation and Development.\textsuperscript{86} Rent regulated buildings too tend to be older, as generally the rent stabilized apartments were built before 1974 and rent controlled apartments were built before 1947.\textsuperscript{87} As anticipated, the vast majority of NOAH buildings are older, low-rise buildings. Finally, Market Rate buildings make up large portions of high-rise and very large buildings. The relative high proportion of pre-war Market Rate buildings compared to post-war Market Rate buildings illustrates the “desirability” of these older, well-constructed buildings.\textsuperscript{88}

![Housing Type Makeup of Age & Size Categories](image)

**Figure 6. Distribution of Housing Types across Age and Size Categories**

**Baseline EUI and Emissions Intensity**

The baseline energy use intensity (EUI) and emissions intensity for the 8,873 multifamily buildings in the cleaned dataset range widely but roughly follow normal distributions, as shown


\textsuperscript{87} “Rent Control FAQ – Rent Guidelines Board.”

in Figure 7. The average building uses 85 kBtu per square foot per year and emits 5.3 kilograms of CO₂e per square foot per year.

Figure 7. Baseline Energy Use and Emissions Intensity Distributions

Figure 8 shows EUI and emissions intensities by building age, size and housing type. One-way ANOVA tests show statistically significant differences in the EUI and emissions intensity distributions across building categories and housing types (p-values are all less than 2e-16, which is significant at the 0.1% significance level). However, no obvious patterns emerge in the data grouped by age and size. One might expect larger buildings to have lower EUIs given that a lower surface area to volume ratio should lead to lower rates of thermal loss. Pre-war buildings appear to follow this expected trend, but the opposite is true for post-war and post-1980 buildings. However, many factors influence a building’s EUI. For example, larger buildings may be more likely to have central air conditioning and low-rise buildings may have no air conditioning at all.

As for housing type, NOAH buildings have the highest EUI and emissions intensity. Again, the ranges of EUI and emissions intensity are similar across housing types, so I cannot draw conclusions from these charts alone.
I performed OLS regressions to further assess the EUI and emissions intensity differences across housing types. Even after controlling for building age, size, and unit density, there are statistically significant differences between several of the housing categories (Table 7).

NOAH and Rent Regulated buildings use about 6 and 3 kBtu per square foot per year more than Market Rate buildings, respectively. The average EUI of all buildings is 85 kBtu/sqft/year, so at the average, NOAH buildings consume 7% more energy per square foot and Rent Regulated buildings consume 3.5% more energy per square foot.
Interestingly, the EUI of Subsidized buildings is not statistically different from that of Market Rate buildings, but the difference in emissions intensity is statistically significant. This is likely due to the types of fuels used in the buildings. Table 8 breaks down the EUI by fuel type and shows that Subsidized buildings use more natural gas and less fuel oil and electricity than Market Rate buildings. In 2019, the emissions factors of grid-purchased electricity and fuel oils were around 40% higher than the emissions factor for natural gas.\textsuperscript{89} Similarly, NOAH and Rent Regulated buildings use more natural gas and less electricity than Market Rate buildings, which I suspect is due to lower rates of air conditioning. This appears to offset the higher EUIs such that no significant differences in emissions intensities exist.

These differences in EUIs and emissions intensities will translate to different levels of impact of Local Law 97.

\textsuperscript{89} 2019 fuel emissions factors in kgCO$_2$/kBtu: Natural Gas – 0.0531, Electricity – 0.0738, Fuel Oil #2 – 0.0742, Fuel Oil #4 – 0.0753, Fuel Oil # 5/6 – 0.0754, District Steam – 0.0470
Table 8. OLS Regressions of Housing Type on Fuel Type Usage

<table>
<thead>
<tr>
<th>Dependent variable:</th>
<th>Fuel Oil 2</th>
<th>Fuel Oil 4</th>
<th>Fuel Oil 5/6</th>
<th>Natural Gas</th>
<th>Electricity</th>
<th>District Steam</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subsidized</td>
<td>-1.96**</td>
<td>-2.22***</td>
<td>0.05</td>
<td>9.15***</td>
<td>-1.96***</td>
<td>-3.09***</td>
</tr>
<tr>
<td></td>
<td>(0.61)</td>
<td>(0.53)</td>
<td>(0.12)</td>
<td>(1.12)</td>
<td>(0.32)</td>
<td>(0.32)</td>
</tr>
<tr>
<td>NOAH</td>
<td>-1.09</td>
<td>-0.67</td>
<td>0.12</td>
<td>15.49***</td>
<td>-6.11***</td>
<td>-2.71***</td>
</tr>
<tr>
<td></td>
<td>(0.58)</td>
<td>(0.50)</td>
<td>(0.11)</td>
<td>(1.06)</td>
<td>(0.30)</td>
<td>(0.30)</td>
</tr>
<tr>
<td>Rent Regulated</td>
<td>-0.38</td>
<td>1.17*</td>
<td>0.19</td>
<td>9.26***</td>
<td>-5.51***</td>
<td>-1.93***</td>
</tr>
<tr>
<td></td>
<td>(0.54)</td>
<td>(0.47)</td>
<td>(0.11)</td>
<td>(1.00)</td>
<td>(0.28)</td>
<td>(0.29)</td>
</tr>
<tr>
<td>Year Built</td>
<td>-0.07***</td>
<td>-0.03***</td>
<td>-0.002</td>
<td>-0.08***</td>
<td>0.08***</td>
<td>0.01**</td>
</tr>
<tr>
<td></td>
<td>(0.01)</td>
<td>(0.01)</td>
<td>(0.001)</td>
<td>(0.01)</td>
<td>(0.003)</td>
<td>(0.003)</td>
</tr>
<tr>
<td>Gross Floor Area (1,000 sqft)</td>
<td>-0.004**</td>
<td>-0.001</td>
<td>0.00002</td>
<td>-0.01**</td>
<td>0.002***</td>
<td>0.01***</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.0002)</td>
<td>(0.002)</td>
<td>(0.001)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>Residential Units Density (sqft/unit)</td>
<td>-0.001*</td>
<td>-0.0000</td>
<td>-0.0000</td>
<td>-0.01***</td>
<td>0.001***</td>
<td>0.002***</td>
</tr>
<tr>
<td></td>
<td>(0.0003)</td>
<td>(0.0002)</td>
<td>(0.0001)</td>
<td>(0.002)</td>
<td>(0.001)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>Constant</td>
<td>152.23***</td>
<td>69.49***</td>
<td>4.60</td>
<td>207.88***</td>
<td>-129.66***</td>
<td>-21.13***</td>
</tr>
<tr>
<td></td>
<td>(12.86)</td>
<td>(11.21)</td>
<td>(2.53)</td>
<td>(23.74)</td>
<td>(6.72)</td>
<td>(6.77)</td>
</tr>
</tbody>
</table>

Observations: 8,873  R²: 0.03  Adjusted R²: 0.02  Residual Std. Error (df = 8866): 17.30  F Statistic (df = 6; 8866): 38.12***

* p<0.05; ** p<0.01; *** p<0.001

Local Law 97 Penalties

In the Business-as-Usual (BAU) case – EUI and emissions remain the same through 2050 – most buildings will be subject to the Local Law 97 penalties, especially beginning in 2030. Table 9 shows the portion of buildings that will be subject to LL97 penalties in 5-year increments. The law officially comes into effect in 2024, and will immediately affect about 17% of buildings. As the limits grow more stringent over time, more buildings will face penalties and the penalty amounts will get larger. For context, the average building floor area is 101,684 square feet and the average apartment size is 1,225 square feet. Table 9 also shows the average penalty per square foot, apartment, and building per year assuming no change in building EUI and energy supply mix.
Table 9. Portion of buildings subject to Local Law 97 penalties and average penalties in business-as-usual case

<table>
<thead>
<tr>
<th>Year</th>
<th>Buildings Subject to Penalties (%)</th>
<th>Average Penalty ($/Sqft/Year)</th>
<th>($/Apartment/Year)</th>
<th>($/Building/Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2025</td>
<td>17.3%</td>
<td>$0.266</td>
<td>$326</td>
<td>$27,032</td>
</tr>
<tr>
<td>2030</td>
<td>81.7%</td>
<td>$0.448</td>
<td>$549</td>
<td>$45,564</td>
</tr>
<tr>
<td>2035</td>
<td>85.6%</td>
<td>$0.496</td>
<td>$607</td>
<td>$50,429</td>
</tr>
<tr>
<td>2040</td>
<td>87.4%</td>
<td>$0.553</td>
<td>$677</td>
<td>$56,193</td>
</tr>
<tr>
<td>2045</td>
<td>87.2%</td>
<td>$0.553</td>
<td>$677</td>
<td>$56,235</td>
</tr>
<tr>
<td>2050</td>
<td>99.4%</td>
<td>$1.010</td>
<td>$1,237</td>
<td>$102,721</td>
</tr>
</tbody>
</table>

The impact of the penalties will vary by building type and between owners and renters. In NOAH and Market Rate housing, where there are few or no rent protections, these penalties could be passed through to tenants via rent increases. The impact of rent increases on the affluent will be less than that for low-income renters. If building owners do not or cannot transfer penalties to tenants, then they may reduce investments in other areas, such as general maintenance and safety, which could lead to worse or even dangerous living conditions, especially in NOAH buildings.

The average penalty per square foot varies across the four housing types. The average undiscounted total penalties per square foot from 2024 to 2050 are $12.40 for NOAH apartments and $7.37 for Market Rate apartments. In other words, adjusting for differences in apartment size, NOAH apartments will face 68% higher penalties than Market Rate apartments. Without adjusting for apartment size, NOAH apartments pay 13% higher penalties than Market Rate apartments.

**Penalty Burden**

To further contextualize these penalties, I calculated the “Penalty Burden,” defined as the increase in rent a tenant would face due to the pass-through of penalties. Figure 9 shows the distribution of penalty burdens for Market Rate and NOAH apartments. The penalty burdens are mostly below 5% in the earlier years, but escalate to 10% to 15% in later years. The penalty burdens are larger for NOAH apartments, partially due to the differences in EUI and emissions intensity discussed above, but mostly due to the lower rents.

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90 “Building Performance Standard Module.”
Figure 9. Tract-Level Median Penalty Burden in 2030, 2040, and 2050. The Penalty Burden is calculated as the penalty amount divided by rent of the apartment.

The average penalty burden in NOAH tracts is 2.5% in 2030, 3.4% in 2040, and 7.3% in 2050. The average penalty burden in Market Rate tracts is 1.9% in 2030, 2.5% in 2040, and 5.6% in 2050. The differences between NOAH and Market Rate penalty burdens are statistically significant at the 0.1% significant level (the p-values of two-sided T-tests are 1.16e-7, 3.02e-12, and 2.20e-16, respectively). These differences are also materially significant, as most low-income households are already rent burdened, meaning they spend more than 30% of their income on housing.\(^9\) As discussed earlier, the more a renter must pay for housing, the less they have available to spend on other essential items, like food and healthcare. Thus, even a 5% increase in monthly rent could initiate the Heat, Treat, Eat Dilemma and result in displacement.

Retrofit Scenarios

For each scenario I present the avoided penalties, energy cost savings, and total cost savings. The total cost savings are the sum of the avoided penalties and the energy cost savings in the Mid-price scenario. The histograms include the results for all buildings and the tables present the mean, standard deviation, and portion of negative values under different discount rate scenarios.

Scenario 1: Gradual EUI Reductions

In Scenario 1, all buildings comply with Local Law 97 through energy efficiency improvements. Because the energy use drastically decreases and the fuel mix remains constant, most building owners and residents would save a significant amount of money on energy costs every year.

Figure 10 shows the energy cost savings, avoided penalties, and total cumulative cost savings for all apartments.

The average apartment would save over $26,000 from 2024 to 2050, or about $1,000 each year on energy costs alone. All buildings would completely avoid the Local Law 97 penalties, which would save the average apartment almost $11,000 from 2024 to 2050, or about $400 each year. In total, the average apartment would save over $37,000, equivalent to roughly $1,400 per year.

As shown in Figure 10, a subset of apartments will realize relatively little cost savings – these are the buildings that already have low EUI and emissions intensity and will need to do very little to comply with Local Law 97. On the other end, several thousand apartments would save over $100,000 or over $3,700 per year.

In Scenario 2, buildings are 100% electrified in 2024, but EUI remains constant from the baseline through 2050. Electricity is more expensive than the other fuel types, so switching to electricity without improved efficiency leads to high energy costs in 99.5% of all buildings. As shown in Figure 11, the increase in energy costs overwhelm the avoided penalties, and total costs increase in almost all buildings.
The average apartment would spend almost $90,000 more in energy costs from 2024 to 2050, or about $3,300 per year. Many apartments would pay double what they would pay for energy in the baseline scenario. The average apartment would save almost $10,000 in avoided penalties, but this only offsets about 10% of the increase in energy costs, so the average apartment would pay $79,000 more in total, or $3,000 per year.

Figure 11. Scenario 2: Energy Cost Savings, Avoided Penalties, and Total Cost Savings

Scenario 3: Fully Electric Passive House in Year 1

In Scenario 3, buildings are 100% electrified and EUI drops to passive house standard levels (38 kBtu/sqft/year). The EUI reduction outweighs the higher cost of electricity in 56% of apartments. For the remaining 44% of buildings, the switch to electricity results in higher energy costs. Most of these buildings had lower baseline EUIs so do not benefit as much from energy efficiency.

As shown in Figure 12, the average apartment would save over $8,000 on energy costs, or $300 per year. Additionally, apartment would avoid over $10,000 of penalties, and in total would save $19,000, or $700 per year. Approximately 70% of apartments would realize costs savings, while 30% of apartments would see cost increases.
Figure 12. Scenario 3: Energy Cost Savings, Avoided Penalties, and Total Cost Savings

Summary

Table 10 summarizes the average total cost savings for each scenario. These savings represent the breakeven retrofit cost – that is, if the apartment or building were retrofit at this cost, the energy cost savings and avoided penalties would recover the upfront capital. Unfortunately, there are limited data on actual retrofit costs for large multifamily buildings. The Urban Green Council published a market analysis in 2019 and estimated retrofit costs could range from $0.20 per square foot for low energy savings and up to $12 per square foot for deep energy savings. The New York State Energy Research and Development Authority (NYSERDA) published several multifamily retrofit case studies, for which incremental retrofit costs ranged from $48,000 to $73,000 per unit. A case study of a mixed-income multifamily building in NYC reports total project costs of about $8 per square foot, or $8,000 per apartment. Washington, D.C. required a study on the costs and benefits of their BPS and found that retrofit costs ranged from $0.50 to $27 per square foot, and averaged $10 per square foot. If the actual retrofit costs in multifamily buildings in New York City are near the average of these estimates or lower, then many of the

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93 “RetrofitNY Cost-Compression Study Phase One: Evaluation of Deliverables and Main Cost Drivers” (NYSERDA, March 2020).
buildings should be cost-effective to retrofit based on energy savings and avoided penalties alone.

Table 10. Summary of Average Total Cost Savings, 2024-2050

<table>
<thead>
<tr>
<th>Discount Rate</th>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
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<tr>
<td>$/Apartment</td>
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<tr>
<td>0%/year</td>
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<tr>
<td>8%/year</td>
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<td>-$23,000</td>
<td>$4,000</td>
</tr>
<tr>
<td>$/Building</td>
<td></td>
<td></td>
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<tr>
<td>0%/year</td>
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<td>$/Square Foot</td>
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<td>$7</td>
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</tbody>
</table>
Discussion

I discuss the results in four parts. First, I draw several conclusions from the retrofit scenarios and further discuss the existing inequities and important non-energy aspects of the benefit-cost analysis. I then make broad BPS design recommendations and conclude by detailing limitations of my analysis and areas for further research and consideration.

Retrofit Scenarios

The baseline histograms show the wide variation in EUI and emissions intensity across buildings. These baseline conditions create very different realities for how each building could and should comply with Local Law 97. Some buildings can continue operating as they currently do through 2050 without facing penalties. Conversely, some buildings will face penalties in the very first year Local Law 97 comes into effect. Given the differences in potential energy savings and avoided penalties, some buildings will be much more cost effective to retrofit than others.

The retrofit scenarios presented above provide several key insights. Scenarios 1 (gradual EUI reductions) and 3 (fully electric passive house) highlight the importance of EUI reduction for avoiding energy costs and penalties. Building envelope and energy efficiency improvements alone can achieve significant EUI reductions. For many buildings, even 10% or 20% reductions in EUI would avoid penalties in the first five or ten years.

Scenario 2 (fully electric) demonstrates the adverse outcomes of electrification without energy efficiency. Simply replacing fossil fuel heating, water, and cooking systems with electric systems will result in modest efficiency gains compared to whole-building, integrated retrofits. In a staged, integrated approach, envelope, lighting, electronic equipment, and air distribution system upgrades reduce the building’s base load. Then, smaller electric heating and cooling systems can serve the load, which reduces the upfront and ongoing costs. Lower electric loads also reduce the strain on the electric grid, which will be an increasingly relevant challenge as thousands of buildings are electrified.

In scenario 2, energy costs increase in 99.5% of buildings. Even if electrification is paired with EUI reductions as in scenario 3, energy costs increase for almost half of all buildings, assuming current electric rates. In New York and many other states, electricity from the electric grid is


much more expensive than natural gas. Drastic efficiency improvements are needed to realize cost savings, which may not be technically feasible, depending on the existing systems. However, if the gap between electricity and natural gas prices narrows, electrification may become more financially feasible. Cities and states have little control over the prices of natural gas and electricity because they are determined by complex global market dynamics. However, cities and states can help bring down the cost of electricity through policies that incentivize or require renewable energy development.

Cities and states can also help buildings and residents reduce their electricity costs by creating opportunities for onsite and community solar development. Some roofs may be suitable or could be retrofitted to support solar panels. The City University of New York created and maintains a tool that building owners and developers can use to estimate the solar potential and financial projections of solar deployment at the building level. The levelized cost of electricity from onsite solar panels depends on many factors – from the building orientation to the financing mechanism. New York City residents are eligible for a range of solar incentives and tax credits that can lower the levelized cost of electricity.

Many roofs cannot support solar; even when they can, the capacity is typically insufficient to meet the building’s electric load. Residents can instead purchase electricity through community solar arrangements. Community solar projects can offer lower electricity costs due to economies of scale. However, not all states have policies that support community solar; cities and states planning to implement a BPS should ensure residents can access lower-cost electricity through community solar or similar arrangements. New York City has numerous community solar projects, and the state provides resources for residents to find and purchase electricity from an approved project. Most community solar arrangements guarantee energy savings, which would shift many of the buildings in scenario 3 from negative to positive cost savings. Other advantages of community solar are long contracts that shield participants from the uncertainty of future energy prices and the opportunity for community-owned solar projects to keep financial and physical assets in the community.

Finally, the electrification scenarios highlight a potential downside of opting for an emissions intensity standard opposed to an EUI standard. Especially in regions like New York and New England, where electricity from the grid has a lower carbon intensity but higher cost than fossil fuels, the focus on emissions reduction incentives may lead building owners to electrify without

also reducing EUI through retrofits. Therefore, a building may comply with the BPS but the residents’ energy costs could increase. Conversely, an EUI target, encourages energy efficiency, leading to both emissions reductions and cost savings.102

**Housing Quality Inequity and Non-Energy Considerations**

The efficiency and quality of housing are unequal across housing types. On average, NOAH apartments are less efficient than Market Rate apartments, which leads to higher energy bills, Local Law 97 penalties, and retrofit costs. In addition to paying higher energy costs and penalty burdens, people living in older, less efficient buildings are also exposed to more health hazards.103 Housing is a key social determinant of health – the non-medical factors that shape a person’s health.104,105 Poor quality housing is linked to many adverse health conditions, including but not limited to lead poisoning, asthma and other chronic respiratory conditions, injury, heart disease, and cancer.106,107 Many old homes still have lead paint; lead exposure can impair a child’s intellectual and behavioral development.108 Poor ventilation is one of the key contributors to asthma and respiratory conditions. Low ventilation rates and drafty exteriors may result in moisture, leading to mold, roaches, and viruses.109 Older buildings almost exclusively use fuel oil, propane, and natural gas for heating. Onsite fuel combustion increases the risk of exposure to harmful substances, such as carbon monoxide, nitrogen oxides, particulate matter, and volatile organic compounds.110 Gas stoves, especially with poor ventilation, have been linked to high rates of childhood asthma.111 Figure 13 shows maps of asthma rates and lead paint prevalence in New York City, which I generated using the Environmental Protection Agency’s Environmental Justice Screening and Mapping Tool.112 Notably, the darkest regions, especially for asthma rates, closely align with the map of NOAH tracts.

102 “Building Performance Standard Module.”
107 Krieger and Higgins, “Housing and Health.”
108 Center for Disease Control and Prevention, “Preventing Lead Poisoning in Young Children,” August 1, 2005.
109 Forchuk, Dickins, and Corring, “Social Determinants of Health.”
Figure 13. Asthma Rates and Lead Paint Prevalence in New York City. The figures are from the Environmental Protection Agency’s EJScreen tool, filtered for Asthma (under Health Disparities) and Lead Paint (under Pollution and Sources).\textsuperscript{113}

Less efficient buildings and higher energy costs expose residents to the risk of price fluctuations such as the price spike caused by Russia’s 2022 invasion of Ukraine. Reducing building EUI through retrofits, as in Scenario 3, moderates unanticipated price increases that disproportionately harm low-income households and reduces the likelihood people will forego heating or cooling to pay for other expenses, such as food or healthcare. Affordable and properly functioning heating and cooling systems are essential for good health, especially for children and older adults.

Lower costs, better health and safety, and greater financial stability all benefit households directly. When cost-benefit analyses include the non-energy benefits, many building retrofits are cost-effective.\textsuperscript{114} However, it is important to also consider the public benefits of building retrofits. At the global level, the costs of not reducing emissions are enormous – climate change will inflict risk and damage on all people, places, and economies across the world. New York

\textsuperscript{113} United States Environmental Protection Agency.

\textsuperscript{114} Caswell, “Win-Win-Win? Evaluating the Climate, Health, and Equity Benefits of Retrofitting Low Income Housing in the US.”
City faces acute risks from rising sea levels, intense storms, and extreme heat, which threaten lives and the city’s infrastructure and economy.

Additionally, the public – through Medicaid and Medicare – bears many of the health costs that poor living conditions create. In New York City, more than 4 million people are enrolled in Medicaid.\textsuperscript{115} Building retrofits could realize millions of dollars in cost savings from reduced public health costs. Including reduced public health costs in calculations shows it is cost effective to retrofit the vast majority of buildings.\textsuperscript{116} The Bronx Healthy Building Program is an example of the recognition of public health costs and benefits as they relate to housing. The Montefiore Health System partially funded and implemented the program to directly reduce asthma and other health conditions that lead to hospitalization.\textsuperscript{117}

Another public benefit is the creation of jobs to support growing demand for energy efficiency and electrification construction projects. Every one million dollars spent on building efficiency creates 15 new jobs.\textsuperscript{118} Local Law 97 will generate retrofit projects in thousands of buildings across the city, leading to demand for thousands of new jobs. The benefits of these jobs will flow to individuals and the city’s economy.

**Policies and Programs to Support Building Decarbonization**

Despite the vast public benefits of building decarbonization, the costs of implementing the retrofits are almost exclusively private costs paid by building owners and tenants. The landlord-tenant split incentive problem already poses a barrier to building retrofits, and the private cost-public benefit dynamic adds yet another challenge. Governments can help overcome this challenge by providing financial and technical assistance to building owners.

**Financial Assistance**

Financial products and loans help building owners access capital to finance retrofit projects. Low-interest loans can make a retrofit project more financially feasible, as shown in the retrofit scenario results where total avoided costs are much greater in the low discount rate scenarios. The New York City Energy Efficiency Corporation (NYCEEC) offers several types of loans,

\textsuperscript{116} Caswell, “Win-Win-Win? Evaluating the Climate, Health, and Equity Benefits of Retrofitting Low Income Housing in the US.”
\textsuperscript{117} “Bronx Healthy Buildings Program Awarded $250,000 to Improve Community Housing, Reduce Asthma Hospitalizations and Create Green Jobs,” accessed April 23, 2023, https://www.montefiore.org/body.cfm?id=1738&action=detail&ref=1236.
which finance 80-100% of project costs. NYCEEC also offers Property Assessed Clean Energy (PACE) financing, which provides a long-term, fixed rate loan that covers 100% of project costs. PACE financing can be transferred if the building is sold, reducing investment risk. Building owners can also use PACE financing for other necessary projects, like asbestos and lead abatement, which are typically ineligible for traditional financing and rebate programs. The Department of Housing Preservation and Development’s Green Housing Preservation Program provides low- or no-interest loans for energy efficiency improvements in mid-size affordable housing.

Building owners can also use financing products other than loans, such as on-bill financing or energy savings performance contracts. Both of these solutions are financed by an energy service company or utility and the building owners and/or tenants pay for the retrofits through the energy savings. Such arrangements alleviate the burden of the upfront and ongoing costs and can help overcome the split-incentive problem.

Subsidies and incentives for electrification and energy efficiency improvements help reduce the upfront costs of building retrofits. Building owners may be eligible for a range of subsidies, including federal tax credits, state weatherization assistance, and utility rebates. The Inflation Reduction Act of 2022 makes more than eight billion dollars available for home efficiency and electrification rebates. It also includes tax credits for many energy efficiency measures. In New York, the State offers several cost assistance and incentive programs, including many specifically for affordable multifamily buildings. The utilities serving New York City – Con Edison and National Grid – also offer multifamily rebates for both market rate and also affordable housing.

There are hundreds of different rebates, tax credits, and financing programs. These programs mitigate a portion of the retrofit costs, but are not always sufficient to make projects financially feasible, especially in affordable housing where capital is scarce and often over-leveraged. Moreover, most incentives have specific requirements and cannot necessarily be combined with

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others. Building owners and project managers face the challenge of sifting through this information, determining how much financial support they may be eligible to receive, and securing financial support from numerous entities.\textsuperscript{127} Several states, the federal government, and research institutions created incentive search tools, such as the Energy Star Rebate Finder, North Carolina State’s Database of State Incentives for Renewables & Efficiency (DSIRE), Massachusetts’s energyCENTS, and Rewiring America’s Inflation Reduction Act calculator.\textsuperscript{128,129,130,131} Unfortunately, many of these resources are designed to help single-family homeowners, so are not widely applicable. Additionally, these tools are not comprehensive, and typically only help building owners identify a certain type of rebate or resources from a specific entity. Moreover, resources can be difficult to navigate and understand because many are only in English. Comprehensive and accessible tools and information are sorely needed to accelerate project planning. In the meantime, many cities and states offer technical assistance programs, which help building owners with financial and technical planning.

**Technical Assistance**

Most jurisdictions with BPS offer covered buildings technical assistance to help them comply with the energy or emissions limits. Technical assistance programs should be widely accessible to building owners and tenants who speak languages other than English. Additionally, technical assistance programs need sufficient staffing and resource capacity. If programs cannot assist all building owners who seek help, then those least able to afford consultants and engineers will be left behind. BPS require thousands of buildings to pursue deep energy retrofits, so technical assistance programs will require tens or hundreds of staff to meet the assistance needs.

In New York City, the NYC Accelerator provides free resources, training, and expert guidance on the laws, technologies, and financing related to upgrading buildings. It also connects building owners to contractors to design and implement building retrofits.\textsuperscript{132} Information is available in more than 80 languages and about 25 experts staff the program. Washington, D.C. launched the Affordable Housing Retrofit Accelerator, which provides technical and financial assistance specifically to multifamily affordable housing buildings.\textsuperscript{133} In Boston, affordable multifamily housing building owners can apply for Technical Assistance Grants to receive up to $10,000 to

\textsuperscript{127} Claire Kramer Mills and Jacob Scott, “Strategies for Financing an Inclusive Energy Transition,” October 2022.
perform comprehensive energy assessments and create a building improvement plan. Buildings owners covered by BPS can also seek technical assistance from the Department of Energy’s Building Energy Codes Program.

**Policies and Programs to Support Low-Income Households**

Given the inequalities across housing types, BPS risk maintaining or even exacerbating the inequities. To avoid adverse impacts, cities and states should create policies and programs within or in parallel to BPS that deliver the benefits of building retrofits without over-burdening low-income households.

**Deeper Financial Assistance**

One way for BPS to directly help affordable housing owners comply is through a fund to assist with the costs of building retrofits. For example, Boston proposed an Equitable Emissions Investment Fund with the revenue from penalties imposed on non-compliant buildings. A board comprised of community-based organization members will allocate funds to improve building performance in environmental justice neighborhoods. Washington, D.C. allocates $3 million per year to affordable housing and rent controlled buildings from funds collected through a fee on all customer utility bills. According to D.C.’s cost-benefit study, this amount would barely cover the retrofit costs of three small affordable housing buildings, so is not sufficient but is a model of a funding mechanism.

**Tenant Protections**

BPS could increase risks of tenant displacement if owners pass penalties and retrofit costs onto tenants. Restrictions on cost pass-throughs could reduce this risk; however, many cities and states do not have legal authority to implement this type of rent control. In some cases, governments and lenders could prohibit building owners from increasing rent by certain amounts, evicting tenants, or selling the building as a condition of financial assistance. To help building owners recover costs without overburdening tenants, these restrictions could limit rent increases to the amount of energy cost savings. If cities and states include some form of tenant protection in BPS, then they should also allocate resources to monitor and enforce these policies.

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136 “Building Performance Standard Module.”
137 “Understanding the Housing Affordability Risk Posed by Building Performance Policies - IMT.”
138 “Understanding the Housing Affordability Risk Posed by Building Performance Policies - IMT.”
139 “Building Performance Standard Module.”
A risk of restricting cost pass-throughs is landlords may respond by underinvesting in other areas of building maintenance in order to maintain their profits. Monitoring this problem at the building level is impractical for already resource-constrained cities and states. Instead, governments could consider allocating funds to owners of rent-regulated properties to help recover capital improvement costs. Building owners should be required to rigorously demonstrate the project finances and improvements in order to receive funds. Building owners should not be eligible to receive funds to recoup the penalties, but could receive temporary funding for building maintenance if they actively plan or work on retrofitting the building to comply with the BPS.

**Alternative Compliance Options**

Cities and states may be inclined to exempt rent-regulated and unsubsidized and subsidized affordable housing from compliance to avoid overburdening low-income households. However, as previously discussed, low-income households should be able to benefit from the many energy and non-energy benefits of building decarbonization. Thus, cities and states should be cautious about making broad exceptions and instead should consider alternate mechanisms for BPS compliance.

BPS can include flexibility for affordable housing compliance by offering different timelines, standards, or penalties. In several BPS, the timeline for affordable housing compliance lags behind commercial and market rate compliance by a few years. For example, qualified affordable housing buildings in St. Louis have two additional years to meet the standard. The additional time can help affordable housing owners plan and schedule energy efficiency investments at a time that fits best with mortgage refinancing schedules.

Other BPS require different standards for affordable housing than for commercial buildings or market rate housing. In New York City, buildings owned or located on land owned by the New York City Housing Authority (NYCHA), buildings that participate in project-based federal housing programs, and buildings in which more than 35% of units are rent regulated do not have to meet specific emissions limits, and instead must implement a set of prescriptive energy savings measures. If policymakers choose to design a prescriptive pathway, they should ensure the measures will achieve meaningful EUI reductions and building improvements. Another option is to require a percentage reduction from the building’s baseline instead of the same

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141 Chapter 3: Maintenance of Buildings.
standard or limit for all buildings. This standard may be more feasible for affordable housing buildings, especially if the building’s baseline lags behind market rate buildings.

Finally, cities and states should consider how to adjust the BPS penalties to be more equitable. For example, the penalty amount could be determined as a function of the appraised value of the building. This could reduce the penalty burden disparities between NOAH and market rate buildings. However, it could also create lower incentives for NOAH building owners to upgrade the buildings and instead pay the penalties, which would further exacerbate the disparities in EUI and building condition between NOAH and Market Rate buildings. Policymakers need to carefully assess this tradeoff to determine the optimal penalty amount to achieve the intended outcomes. Perhaps instead of collecting lower penalties from NOAH buildings, it may be more effective and equitable to provide greater financial resources to NOAH buildings.

Summary of Building Performance Standard Design Recommendations

The first step for cities and states when designing a BPS is to gain a deep understanding of the jurisdiction’s building stock, energy use, and housing affordability. Many cities already collect these data through property databases, housing surveys, and energy benchmarking laws. While data are important for designing and assessing broad impacts of BPS, cities must also engage with communities to understand how BPS will affect residents and building owners. Community engagement is a particularly important part of designing financial and technical assistance programs and ensuring they are actually useful and accessible to the people they aim to serve.

With a clear understanding of the building stock and challenges facing residents, policymakers can better design BPS and adjacent policies and programs to maximize equity. This information can also help cities prioritize resources and programs towards certain building types, housing types, or neighborhoods. For example, in New York City most NOAH buildings are pre-war and post-war low-rise buildings. The New York City Accelerator and Energy Efficiency Corporation can thus prioritize lower-income households by designing outreach, training, financial tools, and workforce programs around the needs of older low-rise buildings.

Cities and states have unique housing stocks and challenges, so each BPS will be different. Below I summarize four key components of BPS that impact the equity implications of these policies. This is not a comprehensive set of recommendations. The Department of Energy, National BPS Coalition, and the Institute for Market Transformation (IMT) have many resources and guides to help cities develop BPS. Policymakers must consider and balance the many aspects of BPS, but cannot lose sight of how each decision will impact low-income households and housing affordability.

142 “Understanding the Housing Affordability Risk Posed by Building Performance Policies - IMT.”
143 “Understanding the Housing Affordability Risk Posed by Building Performance Policies - IMT.”
BPS should be coupled with sufficient financial and technical assistance.

Cities and states can make building decarbonization accessible through a “one-stop shop” where building owners can receive technical and financial assistance. The NYC Accelerator, which is part of the Mayor’s Office of Climate and Environmental Justice, is an example of a comprehensive, personalized, and free assistance program.¹⁴⁴ Such models require significant resources to meaningfully assist hundreds or thousands of building owners. When designing BPS, policymakers must consider the resource requirements and the funding source for a technical assistance program.

Many financing and incentive programs exist today, but more are needed to retrofit affordable housing and maintain affordability. Governments can provide deeper financial assistance by allocating resources proportional to the many public benefits of building decarbonization, like improved public health and job creation. Public and private financial institutions should offer low-interest rates and flexible financing with long amortization periods to work with capital and tax credit schedules.¹⁴⁵

BPS should protect tenants from cost burdens and displacement.

BPS should directly address displacement risks through clauses that prohibit burdensome rent increases and eviction during a specified period following compliance-related building upgrades. To avoid the risks of landlords reducing expenditures on other maintenance and safety measures, policymakers should provide additional funding to help owners of rent-regulated buildings recoup building improvement investments. Many cities and states do not have the authority to regulate rents, but can encourage financial and technical assistance providers to condition their services on similar restrictions.

BPS should allocate funds to cover building retrofit costs in affordable housing.

Cities and states should create a fund that provides free capital for building decarbonization investments in affordable housing, especially in NOAH where access to capital and government programs is limited. The scale of funds and other resources required to support BPS compliance depends on many factors, including the baseline energy use and emissions of the building stock, the costs and benefits of building retrofits, the availability and accessibility of private capital, and more. Policymakers should work with building owners, tenants, and technical experts to estimate the costs of compliance and identify which buildings need the most financial support.

¹⁴⁴ “NYC Accelerator.”
¹⁴⁵ Mills and Scott, “Strategies for Financing an Inclusive Energy Transition.”
Ideally, governments should create a fund from the penalties collected for BPS non-compliance, as Boston’s Equitable Emissions Investment Fund will do.\textsuperscript{146} Where such reallocation is not permitted by state law – like in New York City – cities should use other mechanisms, such as utility bill charges, or work with other organizations, such as healthcare providers, to create a fund.\textsuperscript{147,148}

**BPS should be flexible to meet the needs and challenges of affordable housing, but should not exempt affordable housing from compliance.**

If cities and states properly support affordable housing owners and tenants through the previous three recommendations, then affordable housing should not be exempt from BPS. Policymakers may consider granting affordable housing flexibility in the timing, standards, or penalty amounts.\textsuperscript{149,150} The ultimate goals of BPS are to create cleaner and healthier air and buildings, and affordable housing residents should receive these benefits.

**Limitations and Further Research**

The three scenarios I examined provide a high-level understanding of the costs and benefits of retrofits required to comply with Local Law 97. However, data on the costs and energy savings from deep energy retrofits in multifamily buildings are scarce. Buildings differ substantially, requiring building-level energy modeling and detailed cost information to determine the optimal level of efficiency upgrades.

I did not quantify the non-energy benefits of building retrofits, but recognize this is an essential piece of the cost-benefit equation. Researchers have done some work quantifying the health benefits of energy efficiency, but there is not yet a clear framework or data for how to include private and public health benefits in these analyses.\textsuperscript{151,152} There is a great need for more work in this area to gain broad recognition of the many benefits of building retrofits and decarbonization.

My analysis is also limited by my inability to identify NOAH at the building level, because I identified NOAH at the census tract level. Other studies have used real estate, census, housing,

\textsuperscript{146} “Building Performance Standard Module.”

\textsuperscript{147} “Understanding the Housing Affordability Risk Posed by Building Performance Policies - IMT.”

\textsuperscript{148} “Bronx Healthy Buildings Program Awarded $250,000 to Improve Community Housing, Reduce Asthma Hospitalizations and Create Green Jobs.”

\textsuperscript{149} “Building Energy Performance Standard Targets.”

\textsuperscript{150} “Understanding the Housing Affordability Risk Posed by Building Performance Policies - IMT.”

\textsuperscript{151} Bruce Tonn et al., “Health and Household-Related Benefits Attributable to the Weatherization Assistance Program,” September 2014.

and interview data to identify NOAH buildings, but uncertainty remains.\textsuperscript{153,154} Cities should estimate the quantity and locations of NOAH buildings to design BPS that account appropriately for the opportunities and constraints facing owners and tenants of NOAH buildings. A notable difference between New York City and smaller cities implementing BPS is the sheer number of NOAH buildings covered by Local Law 97 because they surpass the size threshold. New York City has thousands of large NOAH buildings, whereas other cities may have mostly small, several unit NOAH buildings that BPS with 25,000 or 50,000 square feet thresholds will not impact.\textsuperscript{155} It is important for cities to understand the quantity and size of NOAH buildings as they consider reducing the size threshold in the future.

Finally, I limited my scope to the distributional impacts of BPS – how energy costs, retrofit costs, and penalties are already distributed unequally and could continue to be. In addition to distributive equity, policymakers and researchers must also consider other forms of justice, such as recognition, procedural, and restorative justice.\textsuperscript{156,157} All forms of justice require deep engagement with communities and bottom-up, rather than top-down, policymaking. Recognitional justice acknowledges the lived experiences of marginalized people and groups.\textsuperscript{158} In the context of energy justice, recognitional justice could involve listening to and learning from people who suffer from high energy burdens and harms of unsafe housing. BPS must be grounded in these realities. Procedural justice means decisions made by governments are fair, transparent, and accessible.\textsuperscript{159} For BPS to be fair and equitable, policymakers must engage with all residents throughout the design process and ensure everyone’s voice and concerns are heard. Procedural justice also means financial and technical assistance are accessible to those who need it most. Finally, restorative justice requires redressing past harms and stopping the perpetuation of the harm and inequality.\textsuperscript{160} Redistributing resources to people and families whose current economic conditions result from centuries of racist, exploitative policies can begin to redress these harms. Building decarbonization alone cannot close such wide gaps, but it can promote housing and economic equity.

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\textsuperscript{154} “Understanding the Housing Affordability Risk Posed by Building Performance Policies - IMT.”
\textsuperscript{155} “Understanding the Housing Affordability Risk Posed by Building Performance Policies - IMT.”
\textsuperscript{157} Lewis, Hernández, and Geronimus, “Energy Efficiency as Energy Justice.”
\textsuperscript{158} Lewis, Hernández, and Geronimus.
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https://ejscreen.epa.gov/mapper/.


Appendix A. Data Sources and Analysis

The data I used and R code I created to conduct my analyses are available at https://github.com/allieshepard/thesis2023.

All data I used for my analysis are publicly available. Table 11 summarizes the data inputs and sources. The data files are included in the link above.

Table 11. Data Inputs: Descriptions and Sources

<table>
<thead>
<tr>
<th>Data</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy and Water Disclosure Data</td>
<td>Data and metrics on water and energy consumption in privately owned buildings</td>
<td>New York City Open Data Portal[161]</td>
</tr>
<tr>
<td>for Local Law 84, 2017-2019</td>
<td>over 25,000 ft² and in City-owned buildings over 10,000 ft² in NYC</td>
<td></td>
</tr>
<tr>
<td>Local Law 97 Covered Buildings</td>
<td>List of buildings in NYC that are subject to Local Law 97</td>
<td>Sustainable Buildings NYC[162]</td>
</tr>
<tr>
<td>List</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel Emissions Factors</td>
<td>Emissions factors (kgCO2/kBtu) for Fuel Oil #2, Fuel Oil #4, Fuel Oil #5/6,</td>
<td>Local Law 97 statute[163], NYC Department of Buildings[164], Energy Star[165]</td>
</tr>
<tr>
<td></td>
<td>District Steam, Natural Gas, and Electricity</td>
<td></td>
</tr>
<tr>
<td>Energy Prices</td>
<td>Fuel prices ($/kBtu) for Fuel Oil #2, Fuel Oil #4, Fuel Oil #5/6, District</td>
<td>NYSERDA (fuel oil[166], electricity[167], natural gas[168]), Steven Winters Associates (district steam)[169]</td>
</tr>
<tr>
<td></td>
<td>Steam, Natural Gas, and Electricity</td>
<td></td>
</tr>
<tr>
<td>Median Rent Prices</td>
<td>Median rents for apartments in NYC census tracts</td>
<td>2019 American Community Survey[170]</td>
</tr>
<tr>
<td>Rent Regulated Buildings</td>
<td>List of all buildings in NYC with at least one rent-regulated unit</td>
<td>NYC Rent Guidelines Board[171]</td>
</tr>
<tr>
<td>Subsidized Housing Database</td>
<td>List of housing subsidies by building in NYC</td>
<td>NYU Furman Center[172]</td>
</tr>
</tbody>
</table>

[161] https://data.cityofnewyork.us/Environment/Energy-and-Water-Data-Disclosure-for-Local-Law-84-/wcm8-aq5w
[162] https://www.nyc.gov/site/sustainablebuildings/requirements/covered-buildings.page
[166] https://www.nyserda.ny.gov/researchers-and-policymakers/energy-prices/home-heating-oil/average-home-heating-oil-prices#nygov-header
[169] https://assets.ctfassets.net/ntcn17ss1ow9/73gDFE9yMk45H4mEezo18y/f2532fe00d1ae79e1b68d56de4c7524/EFA-Upgrading_NYC_Steam_Systems.pdf
[170] https://www.census.gov/programs-surveys/acs
[171] https://rentguidelinesboard.cityofnewyork.us/resources/rent-stabilized-building-lists/
[172] https://app.coredata.nyc/?mbl=false&ntii=&ntr=&mz=14&vrl=https://thefurmancenter.carto.com/u/nyufc/api/v2/viz/98d1f16e-95fd-4e52-a2b1-
Below I outline the steps I followed to clean and format the baseline data, which I downloaded from the NYC Open Data Portal from the Energy and Water Data Disclosure for Local Law 84 datasets.\(^\text{173}\)

Data Cleaning and Formatting Steps:

1. Combine 2017, 2018, and 2019 datasets into one and rename columns to identify the year
2. Create new variable for emissions intensity by dividing the total emissions by the gross floor area
3. Filter data to only include rows where “Self Selected Property Type” = “Multifamily Housing”
4. Convert unit density from number of units per 1,000 square feet to square feet per unit
5. Convert floor area from 1,000 square feet to square feet
6. Remove duplicate Borough-Block-Lot (BBL) IDs
7. Filter out any rows containing 0, N/A, or “Not Available” in BBL, Floor Area, Unit Density, EUI, or Emissions columns
8. Remove buildings smaller than 25,000 square feet (LL97 cutoff)
9. Remove EUI and Emissions Intensity outliers via the interquartile method
   a. EUI Interquartile range = 20 - 153 kBtu/sqft/year
   b. Emissions Intensity Interquartile range = 1.4 - 9.3 kgCO2-e/sqft/year

Further details of the data analysis can be reviewed at the link above.